A STEP-BY-STEP, ILLUSTRATED GUIDE FROM THE EXPERTS AT MAXIMUMPC

PC HOW-TO GUIDE

POWER UP YOUR RIG TODAY!

100 PAGES OF IN-DEPTH PC ADVICE

- Get more speed for less with an upgrade PG. 6
- Stream your gaming the professional way PG. 58
- Build the ultimate home media server PG. 72
- Create a Raspberry Pi voice assistant PG. 90
- Rescue and repair any Windows 10 install PG. 28

+

CHEAP THRILLS

Build a brand new gaming box for just $300

Volume 01 2017

Future

Windows

iBUYPOWER Recommends Windows

D859

$1949

Windows 10 Home
Intel® Core™ i7-6800K Processor
ASUS X99-E Motherboard
NVIDIA® GeForce® GTX 1080 8GB
16GB DDR4-2400 Memory
256GB SSD + 1TB 7200RPM HDD
iBUYPOWER Noctis Blue Case
Asetek 550LC Liquid Cooling
Wireless AC Compatibility

Z840

$1199

Windows 10 Home
Intel® Core™ i7 7700K Processor
MSI Z270 Motherboard
NVIDIA® GeForce® GTX 1060 3GB
8GB DDR4-2400 Memory
240GB SSD + 1TB SATA-III HDD
24X DVDRW
Chimera 5 Flame Case
Asetek 550LC Liquid Cooling
Wireless AC Compatibility

Z807

$899

Windows 10 Home
Intel® Core™ i5-7400 Processor
MSI Z270 Motherboard
NVIDIA® GeForce®GTX 1050 2GB
8GB DDR4-2400 Memory
240GB SSD + 1TB SATA-III HDD
24X DVDRW
Chimera Snow Case
Asetek 550LC Liquid Cooling
Wireless AC Compatibility

Work easy. Play hard. Windows

Intel, the Intel logo, Intel Core and Core Inside are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries. All content and prices are subject to change without notice or obligation.

SNOWBLIND

World's first LCD Side Panel

*Patent pending

Play great new Xbox games on Windows 10 with the stunning performance of DirectX 12.*

Play great new Xbox games on Windows 10 with the stunning performance of DirectX 12.* Stay connected to your gaming community with the Xbox app. And play where you want with in-home streaming.**

*Games, accessories, and media content sold separately. Limited number of games available in 2016 support cross-device play; additional games to follow. DirectX 12 only available with supported games and graphics chips. Check PC to determine graphics chip compatibility.
** Streaming functionality available in supported games; stream to one device at a time; streaming with multiplayer from Xbox One requires home network connection and Xbox Live Gold membership (sold separately). Xbox One Backward Compatibility feature works with select Xbox 360 games, see http://www.xbox.com/backcompat. Xbox Live and broadband internet required for initial download of game to console.

AS SEEN AT CES2017 LAS VEGAS

'This is genuinely quite amazing...'
--Linus Tech Tips

'iBUYPOWER's Snowblind PC is so jaw-dropping.'
-- Tom's Guide

Learn more at:
iBUYPOWER.com/snowblind

FREE LIQUID COOLING ON ALL DESKTOPS

iBUYPOWER

Order today

ibuypower.com
888-462-3899

ALL Systems are Assembled in the USA.

All iBUYPOWER Systems Come with a FREE 3 Year Warranty & Lifetime Tech Support

Alex Cox

WELCOME

I THINK MANY PEOPLE have lost sight. Whether it's the insidious effect of iPads and phones, or something different altogether, we're all starting to forget what our PCs are for. They're not just boxes to connect to the internet, or expensive ways to play the odd game. They are so much more: a vessel for your artistic vision, a communication device, the best way to consume the world's media.... Basically, we all need to think a bit harder about the things we use our kit for. Thankfully, every issue, my beloved colleagues at *Maximum PC* and *PC Gamer* manage to come up with tremendous ideas, and explain precisely how to get this stuff done. You hold in your hands the essential mix of the past year's finest tutorials and experiments.

There's something for everyone here. I've written about game streaming—both in and out of the home—using tools like Xsplit, Gameshow and even Microsoft's own Xbox app on Windows 10. If you want people to see how good (or bad) you are at flicking a joystick around, we've got you covered. If you want better gaming performance, there's a couple of options in here, from upgrading your current machine to building a brand new HD gaming rig for a paltry $300, all thanks to the effervescent, brilliant, fantastic Zak 'Definitely Did Not Pay Me To Write These Things' Storey. Thanks for the entirely empty brown envelope, Zak.

Windows expert Nick 'Ctrl-Alt-Del' Peers has gone above and beyond here, showing us both how to get rescue-ready for that moment when Win10 inevitably seizes up and refuses to play ball, and also looking into the murky world of process management, giving you a slicker running PC and much improvesd knowledge of its inner workings. I even let myself loose on Windows, going in depth—and, if I'm honest, a little bit mad—on the topic of application installations; if you've ever wondered how to remove software forever, or install things more easily, then shoot on over to p42 where all is revealed at last.

Lastly I'd like to thank our Raspberry Pi crew, whose dedication to making a tiny underpowered computer do amazing things is just wonderful. Even if you don't have a Pi of your own, check out the tutorials towards the back of this publication, since there's very little there that you couldn't do with an older PC if you were so inclined.

If you like what you see here, a subscription to one of Future's excellent monthly magazines is the best way to get more of it. Head to page 98 to get the best PC builds, guides, buying advice and features delivered direct to your door. You won't regret it.

Alex Cox is a contributing editor to Maximum PC. *He really should update that profile picture, which makes him look like he's just slithered out of a greasy swamp.*

↘ submit your questions to: comments@maximumpc.com

MAXIMUMPC

EDITORIAL
Editor-in-Chief: Tuan Nguyen
Executive Editor: Alan Dexter
Issue Editor: Alex Cox
Senior Editor: Jarred Walton
Reviews Editor: Zak Storey
Technology Editor: Bo Moore
Contributing Editor: Chris Angelini
Contributing Writers: Neil Bothwick, Alex Campbell, Nate Drake, Cat Ellis, Ian Evenden, Matt Hanson, Jeremy Laird, Chris Lloyd, Neil Mohr, Nick Peers
Copy Editor: Katharine Davies
Editor Emeritus: Andrew Sanchez

ART
Art Editor: Fraser McDermott
Image Manipulation: Gary Stuckey
Photography: Future Photo Studio

BUSINESS
Vice President, Sales: Stacy Gaines, stacy.gaines@futurenet.com
Vice President, Strategic Partnerships: Isaac Ugay, isaac.ugay@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump, michael.plump@futurenet.com
West Coast Account Director: Austin Park, austin.park@futurenet.com
West Coast Account Director: Brandon Wong, brandon.wong@futurenet.com
West Coast Account Director: Tad Perez, tad.perez@futurenet.com
Director of Marketing: Robbie Montinola
Director, Client Services: Tracy Lam
Director, Retail Sales: Bill Shewey

PRODUCTION
Head of Production UK & US: Mark Constance
Production Controller: Vivienne Calvert
Project Manager: Clare Scott
Production Assistant: Emily Wood

FUTURE US, INC.
One Lombard Street, Suite 200, San Francisco, CA 94111
Tel: (650) 872-1642, www.futureus.com

Global Chief Revenue Officer: Charlie Speight
Vice President, Marketing & Operations: Rhoda Bueno
Finance Director: Ryan Lamvik
HR Generalist: Carla Marcos

SUBSCRIBER CUSTOMER SERVICE
Maximum PC Customer Care,
Future Publishing, PO Box 2024, Langhorne, PA 19047
Website: http://myfavouritemagazines.com
Tel: +44 344 848 2852
Email: contact@myfavouritemagazines.com

BACK ISSUES
Website: http://myfavouritemagazines.com
Tel: +44 344 848 2852

REPRINTS
Future US, Inc., 4000 Shoreline Court, Suite 400,
South San Francisco, CA 94080
Website: www.futureus.com
Tel: 650-872-1642, Fax 650-872-2207

Future

Future is an award-winning international media group and leading digital business. We reach more than 57 million international consumers a month and create world-class content and advertising solutions for passionate consumers online, on tablet and smartphone, and in print.

Future plc is a public company quoted on the London Stock Exchange (symbol: FUTR).
www.futureplc.com

Chief executive Zillah Byng-Thorne
Non-executive chairman Peter Allen
Chief financial officer Penny Ladkin-Brand
Managing director, Magazines Joe McEvoy

Tel +44 (0)1225 442 244

©2017 Future US, Inc. All rights reserved. No part of this magazine may be used or reproduced without the written permission of Future US, Inc. (owner). All information provided is, as far as Future (owner) is aware, based on information correct at the time of press. Readers are advised to contact manufacturers and retailers directly with regard to products/services referred to in this magazine. We welcome reader submissions, but cannot promise that they will be published or returned to you. By submitting materials to us, you agree to give Future the royalty-free, perpetual, non-exclusive right to publish and reuse your submission in any form, in any and all media, and to use your name and other information in connection with the submission.

inside

HOW TO 2017

IN DEPTH

06 UPGRADE YOUR PC: MORE POWER FOR LESS CASH

16 BUILD A NEW GAMING PC FOR $300

28 CREATE A WIN10 REPAIR DISK

34 WHICH RAID?

42 APPLICATION MANAGEMENT

50 TASKS AND PROCESSES

HOW-TO

56 STREAM XBOX GAMES AT HOME

58 STREAM YOUR PC GAMES USING XSPLIT

60 STREAM USING GAMESHOW

64 CREATE YOUR OWN SECURE VPN SERVICE

68 MAKE A USB EMERGENCY KIT

70 MANAGE YOUR PASSWORDS

72 BUILD THE ULTIMATE HOME MEDIA SERVER

74 BUILD YOUR OWN CHROMEBOOK

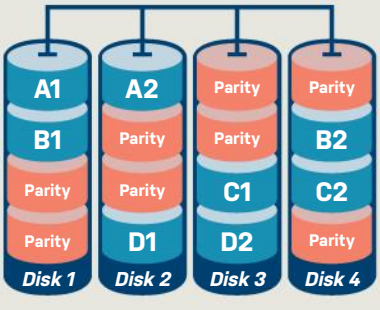
FEATURES

06 UPGRADE YOUR PC: MORE POWER FOR LESS CASH
Get that old box back up to code and enjoy a fresh new computing outlook.

16 BUILD A NEW GAMING PC FOR $300
AMD or Intel? Why not either? Two ace builds that won't cost you megabucks.

28 WINDOWS 10 REPAIR MEDIA MADE EASY
It's all going to go wrong one day. You know it is. And you know you need to be ready when it does.

34 THIS IS A RAID
The mysterious world of hard drives and the data they hold, demystified and properly elucidated.



76 MASTER AIRFLOW

78 CREATE A PI WALL CALENDAR

82 MAKE MUSIC WITH THE RASPBERRY PI

86 BUILD A CHAT ROOM

90 VOICE CONTROL YOUR PI ASSISTANT

94 CREATE YOUR OWN CLOUD STORAGE

TODAY'S BEST UPGRADES

What hardware to upgrade in your ageing machine, and when

THE CONCEPT OF THE UPGRADE PATH is at the very core of the hardware enthusiast's philosophy. The notion that you can take a five-year-old system, throw out a few parts, install a few new ones, and have a rig up and running—which almost competes with a brand new build—in less time than it takes for Obama to drop the mic is certainly appealing. But how far does it go in practice? What makes the biggest difference? And what should you upgrade first?

So here, we decided to find out. We took two case studies, two rigs gathering dust in the corners of our office: one a gaming system, the other a workstation. And then we chose two very different upgrade paths for them both, just to see what makes the biggest difference to overall performance in their respective fields.

The first system was an ageing workstation. Featuring a mighty Core i7-970, this bad boy was Intel's second venture into six-core processors—and coming in at 3.2GHz and $885, it was no slouch. Coupled with a thwomping 6GB of DDR3 1600, a singular 2TB SATA II HDD, and a powerful ATI HIS HD 5870 graphics card, it was a monster in its heyday. Six years on, however, its hard drive is sluggish, the processor on a par with a modern Core i5, and its motherboard support simply laughable. In the other corner is our gaming rig. Far younger than its sibling workstation, this one had fared a bit better over the years. Featuring an Intel Core i5-4670, the Haswell monster still had plenty of computational power to muster—with 8GB of RAM, a 256GB OCZ Vertex 4 SSD, and a reference GTX 670 pumping those frames, you could still game at 1080p, albeit far below the minimum 30fps in most cases.

So, if you're curious about what you should upgrade next, and whether it's worth it, or you just want to take a look at what we did to bring these mature machines back to life, read on.

SAMSUNG
Solid State Drive
CORSAIR
DOMINATOR PLATINUM
DDR4
3200 MHz
DOMINATOR PLATINUM
DDR4
3200 MHz

PRACTICAL ADVICE FOR UPGRADING

THERE ARE PLENTY OF REASONS why we upgrade. They can range from the essential to the vain, from the aspirational to the vital. An upgrade may allow you to hit better frame rates in your favorite games, or give your system enough raw grunt to tackle a title that it couldn't before. If you use your machine for more serious work, an upgrade may allow you to get more done in a shorter space of time, or even do things that you wouldn't have been able to do with your current system.

A reasonable rule of thumb is: If you find yourself waiting for your machine to finish a task, then it could probably do with an upgrade. Whether that's rendering a video, applying an effect to an image, booting, loading an application or website—anything at all, really. Your time is precious, so don't squander it waiting for a machine to complete a task, when technology is there to help. And it doesn't have to be a hardware upgrade that you need; turning to better software, or tweaking the software you're already running, could also be an option—but we'll come on to that shortly.

Of course, there tends to be something holding most of us back when it comes to pulling the trigger on constantly upgrading, and that's the cost. Weighing up the benefits against the price tag is just as important as working out what those hardware updates should be. If your budget can extend to getting the very best component in each category, then all power to you, but most of us can't afford to maintain such an aggressive upgrade regime. If you know that you're going to have to change out several vital components, then planning your upgrade makes sense—buying a graphics card that will still be relevant when you change up your processor and motherboard later.

Knowing what you want from an upgrade is key, because without that knowledge, you're just chasing the next biggest and brightest thing, without taking stock of whether it actually makes sense. Working out what you want to do also enables you to focus on the component or subsystem that will have the greatest impact. Quite often, only you can really know what that area is.

For instance, we wouldn't normally recommend that you spend your time and money upgrading your memory, because for the vast majority of uses, 8GB is enough (or even 4GB, if you're dealing with a much older machine). However, if you're multitasking a lot, editing multiple 4K images, and messing around with UHD video, then doubling up to 16GB or even 32GB could reap real benefits.

Aim for a platform, and reap the benefits of the latest tech.

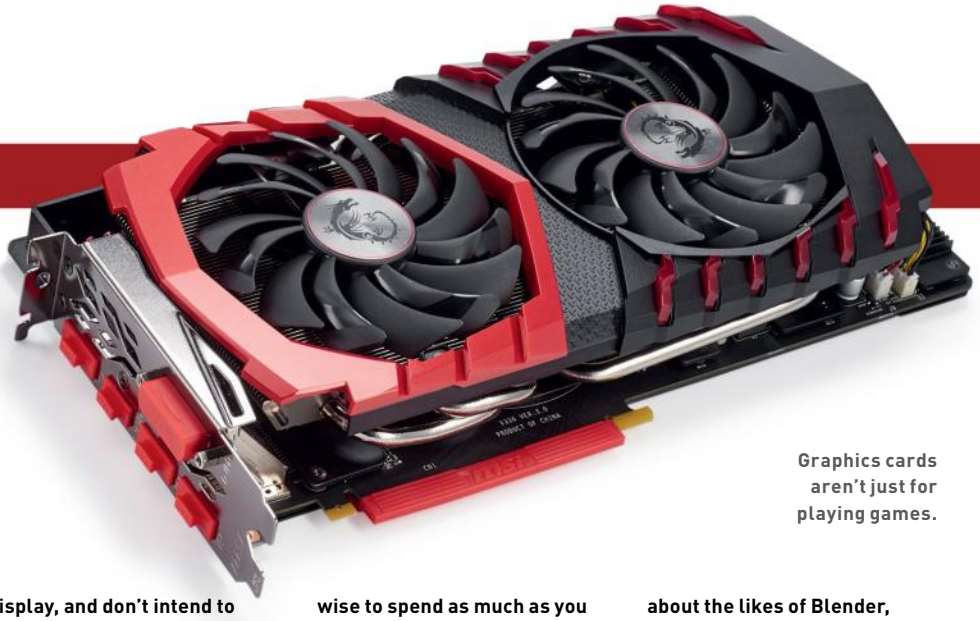
PROCESSORS

Your CPU is at the heart of pretty much everything you do, so there's a certain logic in coveting the very latest processor architecture, and seeing that as the magical panacea to all your computing woes. The problem with this train of thought is that more recent CPU upgrades have been fairly subtle in real terms. In fact, the last few generations have seen raw performance increase by just 10 percent. So, if you miss a generation, there's not too much to get upset about. Miss a few generations, though, and those figures add up (such increases are cumulative).

We haven't seen any major shift in core counts for mainstream processors, and the frequencies have been creeping up reasonably slowly as well. So, even if your CPU is a few generations out of date, that's no guarantee that a CPU upgrade will transform your PC. Indeed, as we found in one of our case studies over the page, a decent CPU from quite a few years ago can still stand its ground against newer chips in practical terms.

There is a fairly major caveat here, though, which is that newer processors support newer technologies, aka the chipsets, and in terms of the bigger picture, this could make a CPU and motherboard upgrade a far more attractive option. M.2 NVMe drives, for instance, can hit transfer rates of 3.5GB/s, as opposed to a lowly SATA SSD, which sits at a meager 550MB/s.

Upgrading your CPU isn't about buying the most expensive chip out there.



Graphics cards aren't just for playing games.

GRAPHICS CARDS

If gaming is something that interests you, you need a graphics card. If you want to play the latest games, you need an up-to-date graphics card. That's pretty much the long and short of it. If gaming is lower down on your list, you probably don't need to upgrade—in fact, you might be able to get away with the integrated graphics capabilities of your CPU. As we say, knowing what you want to use your machine for is key.

As ever with graphics cards, you need to keep your target display in mind when looking at upgrades. There's not a lot of point dropping $800 on a GeForce GTX 1080 if you're happy with your standard HD display, and don't intend to upgrade it any time soon. Buy a graphics card that can drive your display(s), it's that simple. We run plenty of graphics card group tests to help you make the decision on what graphics card is right for you, but just as with the processor market at the moment, there's a good correlation between price and performance—if you're serious about gaming, then it's wise to spend as much as you can to get the performance you need for today's and tomorrow's titles.

Again, there's a proviso, which is to do with using a graphics card for more serious work. Some applications can take advantage of the processing power of a graphics card using CUDA or OpenCL to improve performance significantly—we're talking about the likes of Blender, Maya, and Sony Vegas, among others. The problem is knowing which applications you use actually take advantage of which cards, using which API, and ultimately to what benefit. Check out the software developer's website for the application you're utilizing, to see if there's any advantage to using a specific graphics card.

STORAGE

While processors and graphics cards get the most love in any upgrade decision, they're not the only areas of your system that you should be considering. In fact, we would suggest that another component should be the focus of your passions nowadays, and here we're talking about storage. If you're looking to make just one upgrade in your machine, then upgrading to a modern, speedy SSD will make a tangible difference to pretty much everything you do.

Yes, we know that it isn't traditionally the sexiest bit of computing, but the difference storage can make to how you use your machine can be as obvious as the difference between night and day. This is particularly relevant if you're rocking a spinning hard drive as your main boot device, but also true if you're going from a first- or second-generation SSD up to a modern NVMe M.2 drive. This in turn may require an upgrade to your system's motherboard, which could lead to a new processor, new memory, and more, so as ever, it comes back to what you actually use your machine for.

Do yourself a favor—upgrade to a modern SSD.

There's still a place for spinning storage in modern PCs.

CASE STUDY: GAMING

SO HERE SHE IS, our upgraded gaming machine. From the get go, she came packed with a quad-core processor, 8GB of DDR3, a slightly ageing OCZ 256GB SSD, a 1TB hard drive, and the powerhouse that was the GTX 670. Boy, those were the days, huh? Not too old, we know. This machine was pieced together back in 2013, making it, relatively speaking, still fairly new. And it shows—the motherboard at the rig's heart is still sound. There's an M.2 slot offering up to 10Gb/s transfers, plenty of PCIe slots for additional cards, support for up to 64GB of DDR3, and even onboard power buttons.

Aim of the Upgrade

So, the story behind this system was fairly simple: We assumed that the gamer in question was on a tight budget, they didn't have a lot of cash to throw around, and had only managed to save up for the occasional lump of hardware here and there since it had been originally built. The last and biggest bundle being the motherboard, processor, and GPU combo.

The case was old, probably taken from an office PC from years ago, or a tower the grandparents had used for a while. The power supply was also old, and the storage was somewhat wanting. So, ultimately, we kept it simple and just upgraded the memory capacity and the GPU. Upgrading from Nvidia's GeForce GTX 670 to the GTX 1060 would not only reduce the power draw overhead from the GPU, but also improve frame rates by well over 100 percent.

The Intel Core i5-4670K is by no means the bottleneck in this system—certainly not yet, anyway—but we decided to throw out the old memory in favor of something a little more impactful. So, we grabbed two sticks of 8GB DDR3 to ensure that we could both game and run programs from the desktop without worry.

Free Upgrades?

There's a variety of things you can do to eke out extra performance here and there in a gaming build like this. Keeping your drivers up to date is essential if you want to improve performance. An unoptimized game can benefit by as much as 20–30 percent, purely from a driver pass. Couple that with a gentle GPU overclock, and you can easily crank those frames back up when you begin to experience problems.

Another cheap fix is to increase the number of fans in your build. GPU Boost 2.0 automatically increases the core clock of your graphics card, dependent on the overall temperature, so throwing a couple of extra fans in the front of a chassis, or even on a ventilated side panel, should help keep your card cooler, and let it overclock higher.

However, if you're concerned that your processor may be holding back your GPU, you can throw the multiplier up a fraction to see if that can alleviate the problem. If you're running a stock cooler, as we are here, we suggest leaving the voltage alone entirely, and adjusting the multiplier by two or three at most.

CrossFire Conundrum

An alternative to purchasing a new GPU is to opt for a second older card instead, usually within one to two years of purchasing the first, if you can find one. This can be a good solution to save a few dollars, but it's not without its setbacks. Firstly, SLI and CrossFire profiles aren't always perfect. Generally speaking, on game launch, most titles simply don't have support for any multi-GPU configurations. Which means your second card immediately becomes a paperweight. On top of that, it's likely that you'll end up with trouble in the power supply department as well, if you're not careful, because you can easily add an additional 200W of power draw simply by adding the additional card. On the other hand, getting a more powerful card the first time around, or a newer generation of GPU, will lead you to guaranteed better performance, and better power savings in the long run.

Double or nothing? Two GPUs can yield benefits, but they also increase your power draw.

SPECIFICATIONS

	Base	Upgrades
Processor	Intel Core i5-4670K	
Memory	8GB (2x 4GB) Corsair Vengeance DDR3 @ 1,600	**16GB (2x 8GB) Crucial Ballistix Tactical 1600** *($91)*
Motherboard	Asus Maximus VII Hero	
GPU	Nvidia GeForce GTX 670 2GB	**Nvidia GeForce GTX 1060 6GB** *($299)*
Storage 1	256GB OCZ Vertex 4	
Storage 2	1TB Hitachi 5,200rpm HDD	
Cost		**$390**

1 CPU Ultimately, we decided to forego upgrading the processor. The Intel Core i5-4670K inside this machine holds more than enough potential to handle any game or program we can throw at it. And if we really need to, we can swap out the cooler for something chunkier, and crank those hertz up.

2 GPU Swapping from a GTX 670 to a GTX 1060 made a whole world of difference. We opted to go for the 6GB reference variant in the end for this build, but the frame rate difference between that and the 3GB version really isn't catastrophic. We saw an overall increase of almost double in every game.

3 Memory Upgrading from 8GB to 16GB of DDR3 for this build was purely a quality-of-life procedure. Having access to more memory gives us the opportunity to run VOIP clients, Google Chrome, and recording software, all while running some of the more demanding AAA titles out there.

4 Hard Drives All things considered, the storage situation was pretty sound from the start. A 256GB OCZ Vertex4 is still quite a competitive drive, and backed up by that 1TB drive, it covers all your bases. We would have loved to have changed to a PCIe drive, but for a gaming system, it's not entirely necessary.

THE RESULT

Well, it was always going to be a sure-fire victory for the GPU. The Intel Core i5-4670K is still an extremely competitive core. In fact, unless you're running anything pre-Sandy Bridge, you're unlikely to reach any bottlenecks with regard to gaming and graphical limitations. If this system was going to be sitting in the office for much longer, we would definitely take a look at swapping to a more modern chassis, and potentially go for a newer power supply and better cooling, too—just to reduce noise and for peace of mind. That said, this is a system more than capable of gaming at 1080p and beyond. Not bad for an outlay of just under $400.

BENCHMARKS

	BASE SYSTEM	
Cinebench R15 (Index)	570	568 (0%)
Aida64 Memory Latency (ns)	75.3	73.7 (2%)
CrystalDisk Sequential Read (MB/s)	536	543 (1%)
CrystalDisk Sequential Write (MB/s)	526	527 (0%)
3DMark Fire Strike (Index)	5,735	10,156 (77%)
Far Cry Primal (fps)	35	66 (89%)
Total War: Attila (fps)	18	37 (106%)
Rise of the Tomb Raider (fps)	20	40 (100%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

All games were tested at the maximum possible preset, with HD texture packs turned on. Scores represent average frames per second in those titles, unless otherwise specified.

CASE STUDY: WORKSTATION

THIS IS BY FAR the more interesting build. In fact, its ancient and decaying spec sheet was still far more intriguing than the updates that followed. With one of the world's first six-core consumer processors, 6GB of DDR3, and a prestigious Intel motherboard (yep, it still made them), this system managed to crank out some serious numbers even today, six years on. The hard drive situation was far less desirable—with two SATA II HDDs, it was mostly used a web server, before finally being retired two years ago. Last week, it was a shelving unit. So, what did we manage to salvage?

Aim of the Upgrade

This was the biggy. We knew we wanted to upgrade to a more modern chipset. But a more modern chipset requires a brand new motherboard, and a new mobo requires a new processor, which requires new RAM. Like a cascade effect, upgrading one part meant that pretty much everything had to change. We opted to grab an Intel Core i7-5820K to replace the ageing Gulftown processor—it's cheap, packed with additional PCIe lanes for future upgrades, and supports the latest X99 motherboards. Then we had to decide on the memory, upgrading from a tri-channel 6GB kit of DDR3 all the way up to a 32GB kit of quad-channel Crucial Ballistix Elite.

Motherboard-wise, we decided to go for the EVGA X99 Micro 2. It looks crisp and clean, it performs well, and it fits into our shiny new case well, too. On top of that, it gives us plenty of expandability going forward, enabling us to install two add-in cards if needed. We also fitted a 240GB Kingston HyperX Predator M.2 PCIe SSD—not the fastest of the PCIe SSDs, but it's cost effective, and easily knocks the old SATA II drives out of the park.

Free Upgrades?

There are a couple of free options on a setup like this. We took the old 2TB SATA II drives, and configured them to operate in RAID 0 to boost sequential read and write speeds. To do this, go into your motherboard's BIOS settings, find your SATA configuration panel, and change the storage type from AHCI to RAID. Upon restarting, hold Ctrl, and press I repeatedly to get into the RAID menu. Select the drives you want, choose the RAID setup you'd like, and create away. If you're using RAID 0, it should double your potential sequentials; and if you're using RAID 1, it mirrors the data on to the second drive, so if one drive fails, you always have an accessible backup.

Then there's overclocking. Far more useful for rendering tasks on workstations than on gaming PCs, bumping the Core i7-5820K up to 4.2GHz is relatively easy, and shaves off a significant amount of time from your render cycles.

Pump Up the PSU

For this build, we opted not to swap out the graphics card. As it's not gaming PC, but a content creation workstation, it was unnecessary to move away from a high-end card like the 5870 to something more modern, at least until we start using CUDA for rendering. That said, we had to consider that our operating requirements were going to change dramatically in contrast to the old Gulftown rig.

Using Pcpartpicker.com, we specced up the requirements for our new upgraded system (including older GPUs and hard drives), which provided us with a good estimate of what our overall power usage was going to be (471W at peak). You should always look for a power supply that provides somewhere in the region of 20–25 percent more rated power than your system draws from the wall. That way, you'll never run it at max capacity, and PSUs are generally most efficient when they run at 80–90 percent capacity.

Ensure your PSU is rated to provide about 25 percent more power than your system draws.

SPECIFICATIONS

	Base	Upgrades
Processor	Intel Core i7-970	**Intel Core i7-5820K** *($390)*
Memory	6GB (3x 2GB) Patriot DDR3 @ 1,600MT/s	**32GB (4x 8GB) Crucial Ballistix Elite DDR4 @ 2,666MT/s** *($220)*
Motherboard	Intel Desk Board	**EVGA X99 Micro 2** *($193)*
GPU	ATI Radeon HD 5870	
Storage 1	2TB Western Digital SATA II	**240GB Kingston HyperX Predator M.2 SSD** *($146)*
Storage 2	2TB Western Digital SATA II	
Misc		**Case, PSU, CPU cooler** *($380)*
Cost		**$1,329**

1 CPU The CPU was the second-biggest change we made to this system. Jumping forward by five generations of processor technology has helped to push performance up by almost 35 percent in contrast to the Intel Core i7-970 that was originally found in this machine. A very worthwhile upgrade.

2 Motherboard And now the biggest change we made: the motherboard. Not only did we opt to go with an X99 board this time around, but we also swapped over to microATX in the process. This means we can choose a smaller, more versatile chassis, yet still retain all of the power of the X99 socket.

3 Hard Drives Another massive change for our workstation is the upgrade from the ageing SATA II hard drive to the modern powerhouse of a PCIe SSD. Although it's not the fastest SSD drive out there, the HyperX positively warps space when you compare it to its spinning predecessor.

4 GPU Simply put, this isn't a system for the gamers—it's a system for the designers, the CAD developers, the artists, the videographers, and the photographers. An expensive GPU simply isn't necessary. Could it be used for gaming in the future? Of course, but for the time being, it's far from essential.

THE RESULT

As you can see from the benchmarks, the biggest performance increase stemmed from the hard drive swap. Going from SATA II drives to a PCIe SSD, and using the SATA drives as backup storage is nothing short of incredible. Interestingly, after five years of processor development, Intel's six-core enthusiast chip only beats the Intel Core i7-970 by 35 percent. What's important to note is that the price has plummeted.

Other than that, this upgrade came together nicely. The HD5870 was still more than enough for all the editing we wanted to do. In the long term, however, it might have been nice to change out to a GTX 1060 or RX 480 instead.

BENCHMARKS

	BASE SYSTEM	
Cinebench R15 (Index)	750	1016 (35%)
Aida64 Memory Latency (ns)	70.5	70.6 (0%)
CrystalDisk Sequential Read (MB/s)	132	1,573 (1,092%)
CrystalDisk Sequential Write (MB/s)	131	995 (660%)
CrystalDisk 4K Read (MB/s)	0.7	37 (5,185%)
CrystalDisk 4K Write (MB/s)	1.2	103.7 (8,542%)
PCMark 8 Home (Index)	3,249	3,937 (21%)
3DMark Fire Strike (Index)	2,837	2,844 (0%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

All benchmarks are run three times for consistency, and an average is taken. CrystalDiskMark scores are actually correct.

OTHER TWEAKS AND TRICKS

Chassis are slowly turning into works of art.

CASES

You could say a case is nothing more than six panels of metal holding the components of a system together. In reality, it's much more than that. Cases are an essential part of PC building. Whether you build your own, pinch one from an age gone by, or go all-out and purchase a $400 affair, it's something that every PC user has. But how much of an impact does it make in the world of upgrades? Is it worth upgrading at all? That depends on what you have. There are a few examples where swapping out to a newer chassis provides you with more performance.

Graphics cards from AMD and Nvidia come with a new form of technology known as GPU Boost. This is an auto-overclocking feature that increases or decreases the core clock speed, dependent on the card's temperature. Depending on the size of your case, and the amount airflow, you can affect the temperature of hardware inside. It's why blower fans and dual and triple dissipation card designs exist. Blowers can draw in vast quantities of air from a single vent hole, while the dissipation variety spreads the hot air around the chassis. If you're not providing enough cool air inside a chassis, you'll likely cripple your graphics card's overall performance.

On top of that, there's the ease of access of newer cases, with multiple 2.5-inch drives, better cable management, improved airflow, and support for a wider variety of cooling, motherboards, form factors, and more. So, upgrading your chassis can be very satisfying.

Low RPM fans with high airflow improve temps and reduce noise.

COOLING

Speaking of cooling, it's always a good idea to evaluate your situation. Ambient temperatures are always going to have a dramatic effect on overall internal temperatures. For instance, if you're stuck in Phoenix without aircon, your rig may very easily run at a full 10 degrees higher than, say, someone sitting in Chicago. With that being the case, you're going to need more efficient forms of cooling than a reference stock cooler to avoid thermals throttling your hardware. You can check a lot of this by running a few simple benchmarks, such as Prime95 and Unity's Heaven, alongside HW Monitor, to register just what temperatures your hardware is running at.

There are multiple ways you can help alleviate the throttling situation. Swapping out a reference CPU cooler for something more efficient, such as Cooler Master's Hyper 212 Evo, will help ensure your processor doesn't overheat far better than any stock cooler, and for $30, that's not a bad deal. We also suggest you run at least two intake fans in your chassis to provide sufficient airflow internally, to keep all your components well fed.

If you're thinking about overclocking to boost those performance figures some more, we would suggest you take a look at watercooling, especially when it comes to Intel's latest chips. You don't necessarily need something like a custom loop, but a single 120mm AIO liquid cooler, such as the NZXT Kraken X42 or Corsair Hydro H60i, will provide you with ample capacity to overclock any processor, outside of the extreme edition CPUs.

MEMORY

As DDR4 replaced DDR3 with the introduction of the X99 and Z170 chipsets, it failed to impress many hardware reviewers, purely because it added little to performance figures. Indeed, memory speeds seem inconsequential for the vast majority of users.

Improved capacities and lower power draw, though, mean we're seeing overall wattage requirements plummet. And if you want to upgrade your memory, we recommend you choose capacity over speed, and get the capacity you need: 8-16GB for gaming and everyday tasks; 16-64GB for video rendering and 3D modeling. Speed isn't a necessity.

DDR4 performance increases are negligible, but with increased capacity, it's a no-brainer.

If you're gaming, remember to match your screen to your GPU.

MONITORS

If you're not into gaming, upgrading your screen is a relatively painless affair. For professionals and graphic designers, the obvious route is to grab yourself one of those swanky IPS panels. Providing far better color reproduction, IPS and PLS are exceptionally useful for those looking for color accuracy from screen to printer. On top of that, there's the argument of resolution and screen real estate. Bumping up the size of your screen in conjunction with resolution, to maintain your pixel per inch ratio while also increasing screen real estate, makes it far easier to work on multiple programs at the same time. Going from a 24-inch 1080p screen to a 27-inch 1440p screen is a joy, and well worth the time of day.

That said, on the other side of the fence, for gaming it's a little more complex. Your screen choice is inherently symbiotically joined at the knee with your GPU. Choosing the right screen is dependent on what graphics card you have, what games you play, and what resolution you want to achieve. Working backward, if you're looking at gaming at 1080p, the RX 480 or GTX 1060 is a fine combination; at 1440p, the GTX 1070 or Fury X is a perfect solution; for 4K, you can almost get away with a GTX 1080 with some lower AA settings. For high refresh rates at 1440p, the GTX 1080 is the king.

MOTHERBOARDS

Motherboards are by far one of the most underappreciated components in any given system. And it's not hard to understand why, either. Marketing gurus throughout the industry have been promoting these "performance-enhancing pillars of computing" for quite some time. If it's not Killer Networking touting a whole 200ns faster speeds than its Intel rivals, it's efficient capacitors, gaming technologies, and whatever else the whizz-kids want to slap on to each box to bump up the price tag.

That said, once you've waded through the mire of marketing sludge, and got to the grunt of what makes Intel's constant chipset updates more interesting than most, the whole concept is actually more intriguing than you would first think.

It's the enhanced connectivity that really sells it. Take a look at Z170, compared to last generation's Z97 chipset, and you'll see what we mean. Each generation sees improved support for a wide variety of connection standards. M.2 SSDs, which were so rare two years ago, are now commonplace, providing read and write speeds up to six times faster than any SATA SSD, and Intel accommodated for that.

Marketing spiel aside, higher priced motherboards generally tend to feature improved onboard audio, alongside more efficient VRMs, meaning you can operate higher overclocks and low undervolts on your system with ease.

Chipset is still king.

CHIPSET ADVANCEMENTS

	Intel Z97 Chipset	Intel Z170 Chipset
PCI Lanes	8x PCIe 2.0 @ 5Gb/s	20x PCIe 3.0 @ 8Gb/s
USB 3.0 Ports	6	10
USB 2.0 Ports	14	14
SATA Ports	6	6
DMI	2.0	3.0
DDR Support	DDR3 @ 1,600	DDR4/DDR3L @ 2,133/1,600

WE'RE SET NEW CHALLENGES, of all kinds, all the time. Whether it's via our executive editor, our editor-in-chief, or the management bods who want those big headlines on the newsstand, we're thrown into the belly of the beast with a new conundrum to tackle. Every time they come, those challenges get more extreme. This time, we were sat down and told: "$300— that's your budget. We want a 250GB SSD, and 8GB of memory. Do it!"

And so here we are. Maximum performance at the absolute minimum budget. A base system that can operate efficiently and quickly, yet is fully capable of being upgraded to compete with some of the most prestigious mid-range gaming or office PCs out there. But who are we if not suckers for punishment? Instead of one single $300 bunker-busting bomb, we decided to pit those two old processing dogs against each other—Intel versus AMD—in the ultimate budget build-off, to finally settle the debate once and for all (or at least until Ryzen and Kaby fully launch, and we have a whole plethora of new parts to consider).

AMD INGREDIENTS

PART		PRICE
CPU	AMD A8-7600 3.1GHz Quad-Core	$69
Mobo	Asus A68HM-K MicroATX	$47
RAM	8GB (2x 4GB) Patriot Viper 3 DDR3-1600	$46
SSD	Kingston SSDNow UV400 240GB 2.5-inch SSD	$68
Case	Fractal Design Core 1100 MicroATX	$35
PSU	EVGA 450B 450W 80+ Bronze Certified	$37
TOTAL		$302

INTEL INGREDIENTS

PART		PRICE
CPU	Intel Pentium G4400 3.3GHz Dual-Core	$55
Mobo	Gigabyte GA-H110M-S2H MicroATX	$63
RAM	8GB (2x 4GB) HyperX Fury Black DDR4-2400	$52
SSD	Crucial MX300 275GB 2.5-inch SSD	$81
Case	NZXT Source 210 ATX	$40
PSU	Corsair CX500 500W 80+ Bronze Certified	$50
TOTAL		$341

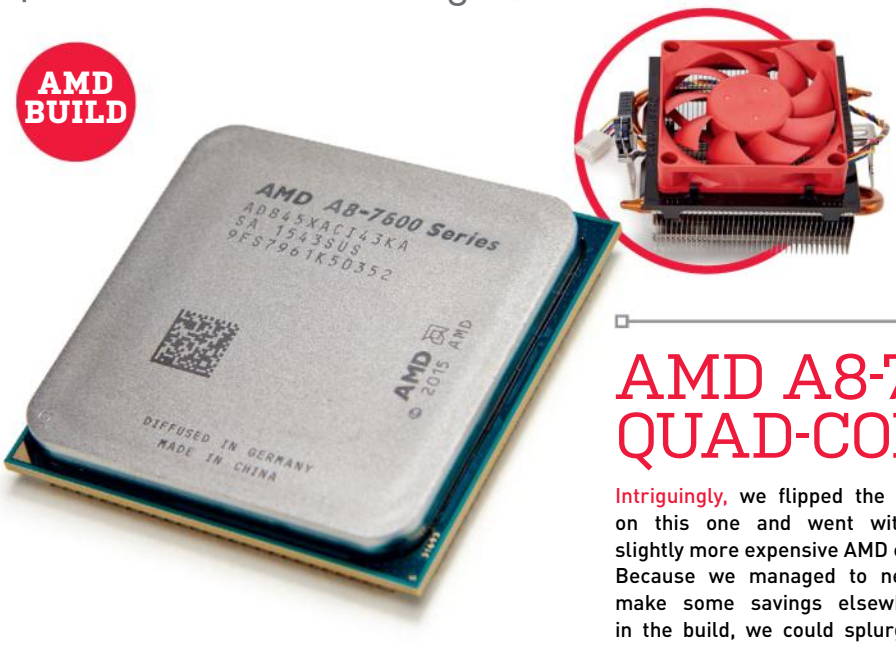
Prices correct at the time of going to press.

$300 BUILD IT CHALLENGE

Two builds, two processors, two teams, and a $300 budget

BY ZAK STOREY

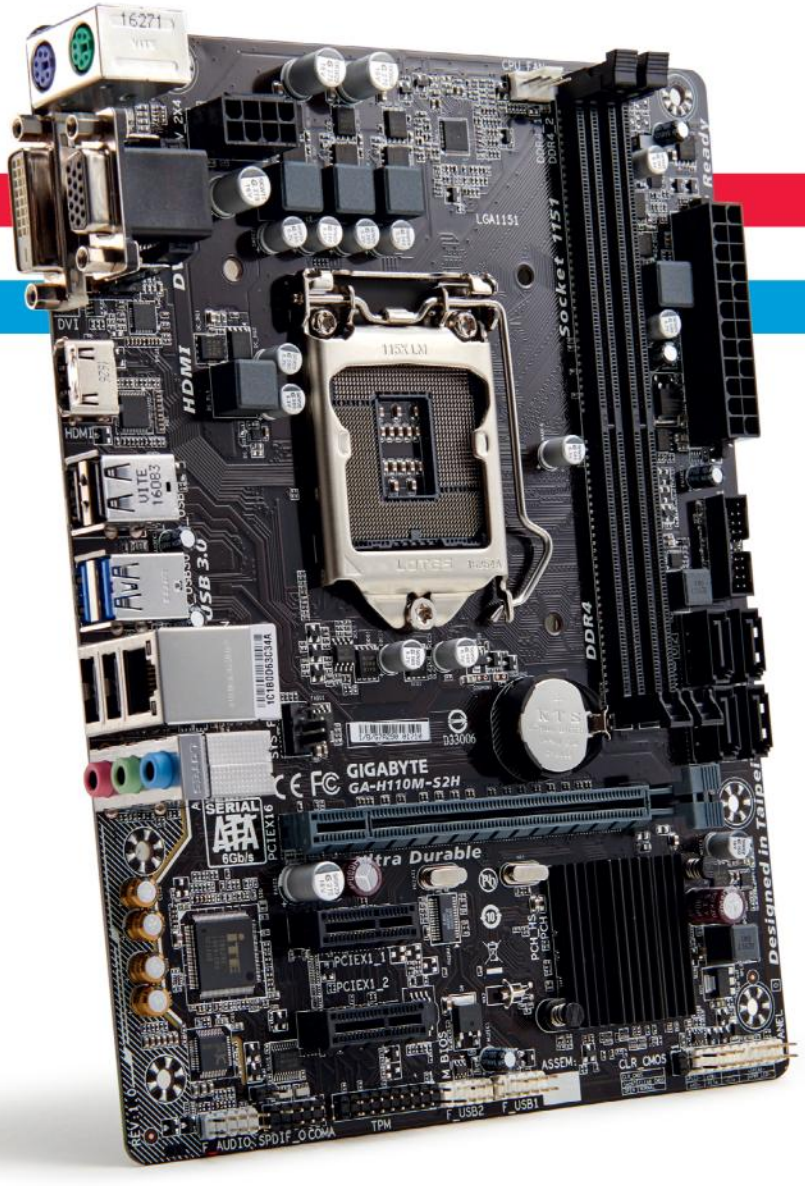
AMD BUILD



AMD CPU

AMD A8-7600 3.1GHZ QUAD-CORE $69

Intriguingly, we flipped the boat on this one and went with a slightly more expensive AMD chip. Because we managed to neatly make some savings elsewhere in the build, we could splurge a touch more, so opted to go for the now-slightly-ageing quad-core A8-7600. Although AMD does have the X4 845 at a slightly cheaper price point, the lack of integrated graphics is a real deal breaker. We'll be honest: We pinched this cooler from an A10-7670K, but rest assured, both this and the Intel chip do come with stock coolers as pictured, so there's no need to worry about your chip overheating.



INTEL MOTHERBOARD

GIGABYTE GA-H110M-S2H $63

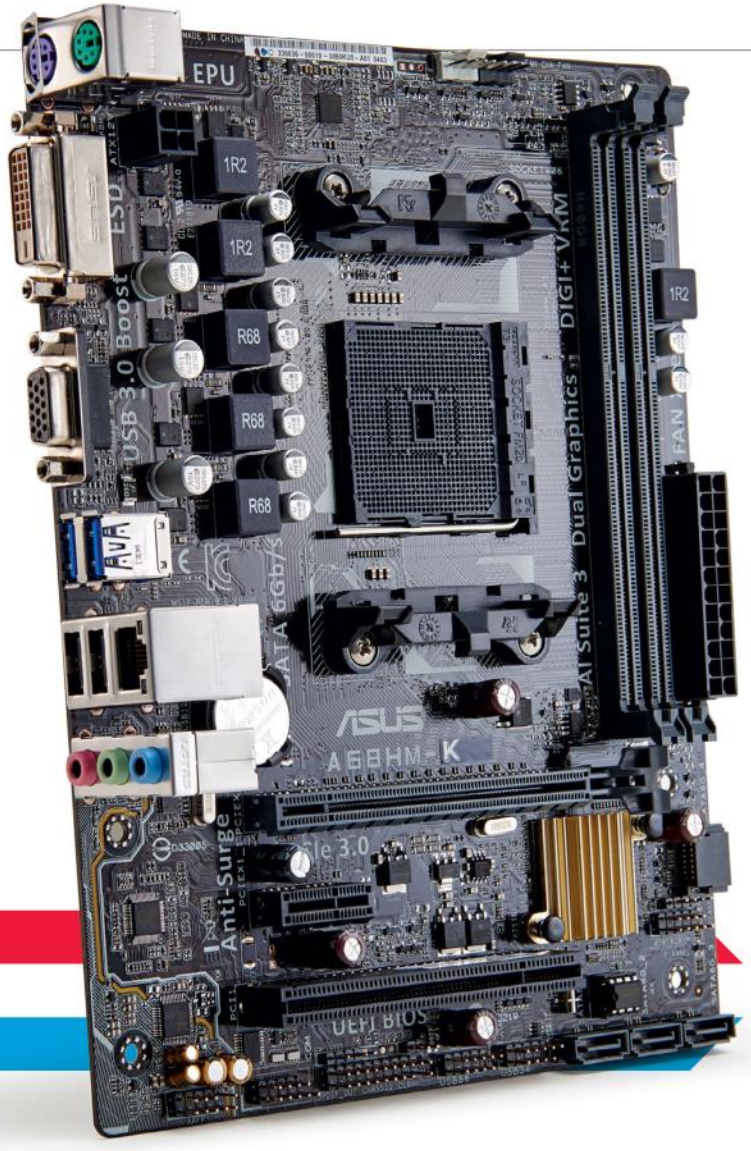
Gigabyte's a fond favorite of ours, providing good-quality motherboards, jam-packed with features at a respectable price. Well, at least once you hit the $100 mark, of course. To even attempt to reach our allocated Intel budget, we had to settle for the H110 chipset. What this meant was a microATX form factor motherboard, with USB 3.0, a single PCIe 3.0 slot, no M.2 support, semi-acceptable audio (fortunately), four SATA 3 ports, and an HDMI connection as a backup. Not exactly perfect, but not too shabby either.

AMD MOTHERBOARD

ASUS A68HM-K

$47

More budget offerings—this time from another favorite: Asus. The A68HM-K is a microATX budget mobo, primed with an FM2+ socket ready for any of the Kaveri line of processors. With relatively slim pickings on board, you net access to four SATA 3 slots, two USB 2.0 headers, two PWM fan headers, and a very limited set of rear I/O. It's almost plain sailing if it weren't for the lack of HDMI connectors. Time and again, we've slated AMD for being too many chipsets behind its rival, and the A68HM-K makes that painfully obvious. However, budget is budget, and you can still equip this with dependable SSD storage, 16GB of DDR3, and any of the latest and greatest GPUs.



INTEL CPU

INTEL PENTIUM G4400 3.3GHZ DUAL-CORE

$55

The old adage states that if you're on a budget, you'll get better value per buck by hopping over to AMD. Although that has become somewhat diluted in recent years, it is still true in essence. So, our choice of Intel's Pentium G4400 is on the bottom rung of Team Blue's processors. But, featuring two 14nm cores, Intel Iris HD 530 graphics, and 3MB of L3 cache, it touts support for Intel's latest and greatest chipsets, alongside some phenomenally beefy single-core performance for the price.

INTEL BUILD

AMD BUILD

AMD MEMORY

8GB (2x 4GB) PATRIOT VIPER 3 DDR3-1600 $46

DDR3 may not be the latest memory technology, but it's still more than sufficient when it comes to normal day-to-day operations and even gaming. With slightly higher latencies, lower capacities, and increased power draw, you're not losing out on much in contrast to DDR4. We chose 8GB of Patriot memory here, because it's the absolute minimum amount we recommend for any new build, and Patriot is a brand that we've come to trust to provide good-quality components, along with a solid warranty. The only downside is that, in the long run, it's not going to be as easy to upgrade with as the DDR4 kit featured in the Intel build, because all the latest platforms are finally shifting across to the new standard.

INTEL SSD

CRUCIAL MX300 275GB SSD $81

This is arguably one of the few places you could shave money off those budgets. Running a system off a single 120GB SSD has been the norm for quite a few years, but as both these configurations lack any additional storage in the form of a traditional spinning hard drive, we decided that bumping up the SSD with a chunk of extra gigabytes would waylay some of those storage woes later on down the line. Crucial's MX300 series is a solid-performing, well-priced range of SSDs, built by the respectable foundries of Intel's partner company, Micron. With reads and writes well above the 500MB/s mark, this is well worth the cash.

AMD SSD

KINGSTON SSDNOW UV400 240GB

$68

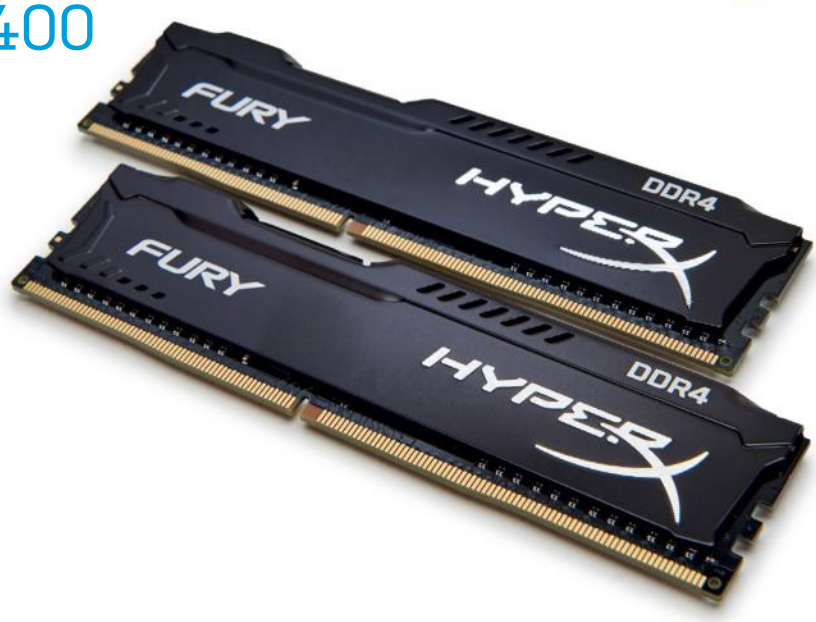
Another circa-250GB SSD hitting the block here. This time, it's a slightly smaller offering than the Crucial MX300, but no less of a performer. This budget-busting solid-state drive performs well into the 500GB/s range as standard, and comes at the astronomically low price of $68. Although that may look cheaper than the Crucial MX300, you have to bear in mind that you do lose an additional 35GB, so the price of the two drives is almost identical when it comes to dollar per gigabyte. You could always get away with a 120GB SSD instead, to drop the overheads, but we feel that double that capacity will keep you happy long-term, until you decide to upgrade at a future date.

INTEL MEMORY

INTEL BUILD

8GB (2x 4GB) HYPERX FURY BLACK DDR4-2400

$52



Eight gigabytes is widely regarded as the absolute minimum amount of memory you should be looking at when building any new system on a modern platform. DDR4 is the go-to for any new Skylake-based system, and, surprisingly, 2,400MT/s is actually just as cheap as the 2,133MT/s kit. In reality, Gigabyte's GA-H110M-S2H can only support DDR4 up to 2,133MT/s, so we would be running this kit at a slightly lower frequency than its advertized spec—but, honestly, you wouldn't be able to tell the difference, and it does provide you with some future-proofing if you want to swap out to another motherboard later down the line.

AMD BUILD

AMD PSU

EVGA 450B 450W 80+ BRONZE CERTIFIED $37

EVGA has constantly impressed us ever since it first launched its range of power supplies, because it provides some fantastic value options, all the way up to the most premium of Platinum-punching PSUs. The EVGA 450B is a 450W Bronze-certified power supply, and is more than capable of supporting this system, even if we wanted to include an additional GPU later down the line. It's a non-modular, ATX-sized variant, granted, but for the price, plus the included warranty, and EVGA's legendary reliability, this a is no-brainer for anyone on a tight budget.

INTEL BUILD

INTEL CASE

NZXT SOURCE 210 ATX CHASSIS $40

This is the ATX budget case of choice, as far as we're concerned. For $40, you net yourself a full-sized midi tower capable of housing an ATX motherboard, multiple fans to support cooling, 5.25-inch drives, and a plethora of 3.5-inch hard drives. Unfortunately, there's no easy way of mounting 2.5-inch SSDs, but with a bit of double-sided sticky tape, you can hide them or mount them on the floor or side of the chassis without worry. We're using the Elite version of the S210 here (as NZXT doesn't sample cases any lower than that), but the only difference between the two are the included fan, and the tool-less 5.25-inch and 3.5-inch bays.

Windows

Sleek and Modern.

The best Windows ever for gaming.

Gaming just got even better with Windows 10. Not only do your existing PC games work great, but now you can also play great new Xbox titles on your PC, including Gears of War 4 and Halo Wars 2.

**Games and media content sold separately. Gears of War 4 coming Fall 2016; Halo Wars 2 coming late 2016. PC hardware requirements may vary for games on Windows 10.*

iBUYPOWER Recommends Windows

iBP SLATE

$1099.00

Windows 10 Home
Intel Core i5-7600k Processor
8GB DDR4-2400 Memory
AMD Nvidia GTX 1060 6GB
240GB SSD
1TB SATA-III Hard Drive
MSI Z270 MotherBoard
iBUYPOWER Slate Case
***TEMPERED GLASS PANELS
FREE KEYBOARD, MOUSE, GAMDIAS HEADSET

Work easy. Play hard. Windows

Available at:
ibuypower.com

iBUYPOWER

All iBUYPOWER Systems Come with a FREE 1 Year Warranty & Lifetime Tech Support

ALL Systems are Assembled in the USA.

Intel, the Intel logo, Intel Core and Core Inside are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries. All content and prices are subject to change without notice or obligation.

Future

MAXIMUM PC AT ITS BEST
ANYTIME, ANYWHERE!

PENTIUM G4600
Intel's new budget wonder reviewed PG. 85
TOPPLING THE CORE i5
Build It: How many cores do you need to game? PG. 72
TOP FREE ANTIVIRUS
It's time you replaced Windows Defender PG. 20
MAXIMUM PC
MINIMUM BS • SPRING 2017 • www.maximumpc.com
SPEED UP WINDOWS
Clear out the junk to boost performance
Optimize your drives for faster boot times
Get a faster system in a few easy steps
HUGE SCREEN SHOWDOWN
HDR, 4K, quantum dot explained PG. 26
Future
$7.99US
03>
0 71486 01028 9
NO.1 FOR PC HARDWARE
SPEED UP WINDOWS 10

Print or Digital subscriptions available!

http://bit.ly/MaximumPCSubs

AMD CASE

FRACTAL DESIGN CORE 1100 MICROATX CHASSIS $35

It's not the fanciest chassis out there, but for the price, it's hard to find much better. Fractal's Core 1100 offers a simple yet somewhat antiquated design, ideal for anyone looking to build their first system. Only supporting up to microATX motherboards, it does limit your upgrade potential, and the lack of cooling support beyond the front 120mm fan is a little unnerving, but you can still build a snazzy little system inside, without taking a huge hit on performance. The top-mounted PSU is a little old-school, but it does help improve internal airflow inside the chassis by shifting more air out of the rear, and if cooling becomes a worry, you can always mount a 120mm fan on the side panel.

INTEL PSU

CORSAIR CX500 500W 80+ BRONZE CERTIFIED $50

We'll be honest—you could easily get away with using the EVGA 450B PSU we suggested for the AMD system on this config. In fact, even if you added an additional hard drive and modern GPU, neither system would be pulling more than 250W from the wall under load. However, we wanted to showcase two separate power supplies for this feature. There's very little difference between the two, though, short of manufacturer—however, brand loyalty, in this case, does cost you. Generally speaking, though, if you do plan on upgrading, we would suggest you invest in a Corsair RM series power supply, to reduce cable clutter with a relatively cheap modular PSU.

AMD'S BONKERS BUDGET BOX $300 PRICE TAG ACHIEVED

OUR AMD BUILD looks quite dainty compared to Intel's behemoth. The microATX Core 1100 offers little room for cable management, though. We tucked a lot of the cables inside the 5.25-inch bay, while sticking the Kingston SSD to its side with double-sided tape.

We contemplated using AMD's more price-aggressive and newer X4 845 quad-core CPU, but it lacked integrated graphics. So we opted for the three-year-old A8-7600. Still featuring a quad-core processor clocking up to 3.8GHz, it should be a meaty choice. However, we had trouble getting it to clock any higher than 1.9GHz with 50 percent utilization in most of our CPU-intensive benchmarks. It took several reinstalls of the chipset and some BIOS tinkering to get it to hit the mark, and even then consistency in other benchmarks failed on several occasions.

We were impressed with how well it ran in-game, though. Even with that ageing APU architecture, frame rates in *Rise of the Tomb Raider* (on low settings at 728p) were impressively comfortable, nearing 30fps, demolishing Intel's Iris HD 530 graphics. All of which bodes well for the low-end offerings coming up with Ryzen, too.

Simply buying a better graphics card and throwing a larger hard drive at it may not be the best upgrade choice. AMD's single-core performance has always held it back and can lead to bottlenecks. It's pricier, but for gaming we recommend investing in an A10-7890K for better single-core performance, on top of the 500GB HDD and GPU of your choice, bumping the upgrade price up to $300. If it's a home theater you're after, a low-end GPU might do you more favors, with an RX 460 2GB and 1TB HDD setting you back $140.

AMD BENCHMARKS

Cinebench R15 Single-Core	80
Cinebench R15 Multi-Core	240
AIDA64 Memory Latency	114.5ns
SiSoft Sandra Memory Bandwidth	10.5GB/s
CrystalDisk Sequential Read	553MB/s
CrystalDisk Sequential Write	485MB/s
PCMark 8 Home Accelerated	2,401
PCMark 8 Work Accelerated	3,522
Rise of the Tomb Raider @ 768p	26fps

Rise of the Tomb Raider was run at 1366x768 on integrated graphics at the lowest possible settings. Average frames recorded in the integrated benchmark.

INTEL'S STEAL OF A SYSTEM COULD HAVE BEEN CHEAPER

WHEN IT CAME to building this PC, the most important decisions revolved around how best to attempt the cable management, and what limited cooling you could achieve with the included fans.

Overall setup was a cakewalk. A quick installation of Gigabyte's chipset and motherboard drivers gave us a rig that ran smoothly with little issue. Getting the games up and running was trickier, with most erroring on first attempt. We found we had to directly install the VGA driver from Gigabyte's site, something we usually leave to Windows Update, then force a DirectX install on top of that.

Choosing which game to benchmark was tricky, as we didn't meet the minimum spec for a lot of them. *Metro 2033* was our first attempt, but upon successive crashes, we caved in and opted for an old favorite, *Rise of the Tomb Raider* (at the lowest settings and 1366x768). Impressively, on integrated graphics we managed an almost watchable 11fps in-game. Although that doesn't sound like much, you could play some of the older classics at lower resolutions without too much of an issue.

In its current state, the Intel machine breaks our $300 budget by 41 bucks. It would've been possible to drop that price simply by shrinking the SSD and using a cheaper EVGA PSU, but we advise sticking with a named brand in case of power surges. That aside, for day-to-day office use, it's exceptionally good value for money. If you were looking at upgrading in the long term, for gaming we suggest grabbing a 500GB HDD and potentially a GTX 1050 or RX 470, for around $143 in total. For a home theater machine, simply grab yourself a 1TB HDD for around $50, and you'd be on to a winner.

INTEL BENCHMARKS

Cinebench R15 Single-Core	137
Cinebench R15 Multi-Core	271
AIDA64 Memory Latency	62.6ns
SiSoft Sandra Memory Bandwidth	22.6GB/s
CrystalDisk Sequential Read	531MB/s
CrystalDisk Sequential Write	503MB/s
PCMark 8 Home Accelerated	2,952
PCMark 8 Work Accelerated	4,130
Rise of the Tomb Raider @ 768p	11fps

Rise of the Tomb Raider was run at 1366x768 on integrated graphics at the lowest possible settings. Average frames recorded in the integrated benchmark.

AMD BUILD

1 SSD MOUNTING
Along with some double-sided sticky tape trickery, we've also threaded the SATA power through the bottom of the 5.25-inch bay to keep it tidier.

2 FRONT I/O ANNOYANCE
Due to a lack of any cable routing options, and a front 80mm intake fan, cable-tying the front I/O cables is a necessity.

3 TOP-MOUNTED PSU
It's a little old-school, but the top-mounted power supply isn't too much of an issue—however, we would suggest installing it before anything else.

1 CABLE MANAGEMENT
Fortunately, the Source 210 comes with plenty of cable management room in the rear, so we managed to route the vast majority of the cables out of sight.

2 HIDDEN SSD
We actually managed to tuck the Crucial MX300 right out of the way in the 5.25-inch drive bay, keeping it out of sight, but easily accessible.

3 FRONT I/O CONNECTORS
The only problem with having a microATX board in a full-sized ATX tower is that you end up stretching the front I/O connectors all the way up.

INTEL BUILD

BUILD THE ULTIMATE WINDOWS REPAIR DISC

Turn panic into minor irritation by crafting your own customized recovery disc *with Nick Peers*

One of the most stomach-churning moments in any PC user's life is when you switch on your computer to do some work or let off some steam, only to find Windows won't boot. You may get lucky—Windows 10 is smarter than previous versions, and can resolve certain issues on its own, but in many cases, you're left in an endless reboot loop. Assuming Windows even gets that far.

If Windows can't fix itself, what next? Do you have a recent backup of your data? What about Windows itself? Of course, it's perfectly possible to reinstall Windows from scratch, but that's the best part of a day lost to restoring your PC. And did we mention your data?

The solution lies in creating a bootable recovery disc—one that gives you the tools to repair most Windows woes, remove malware, and lets you pull data off the drive in case you're forced to bite the bullet and reinstall. In an ideal world, you'd be able to build a single rescue disc to cover all your needs. Linux users can smirk at this point, and bring out their Live CDs, giving them full-blown access to the OS they know and love. Wouldn't it be great if you could do the same in Windows?

The answer is: you can. In this feature, we'll show you how to create all the recovery media you'll ever need. The first disc will give you access to basic Windows recovery options, plus allow you to reinstall Windows if all else fails. The second offers more quick fixes to resolve common boot and loading problems, plus provides opportunities to recover files and back up or restore disk images. The final disc gives you the closest thing to a Linux Live CD: a fully functioning Windows-like environment to work in, with tools to help you troubleshoot problems, get online, and even add your own custom apps to beat malware and perform other tasks.

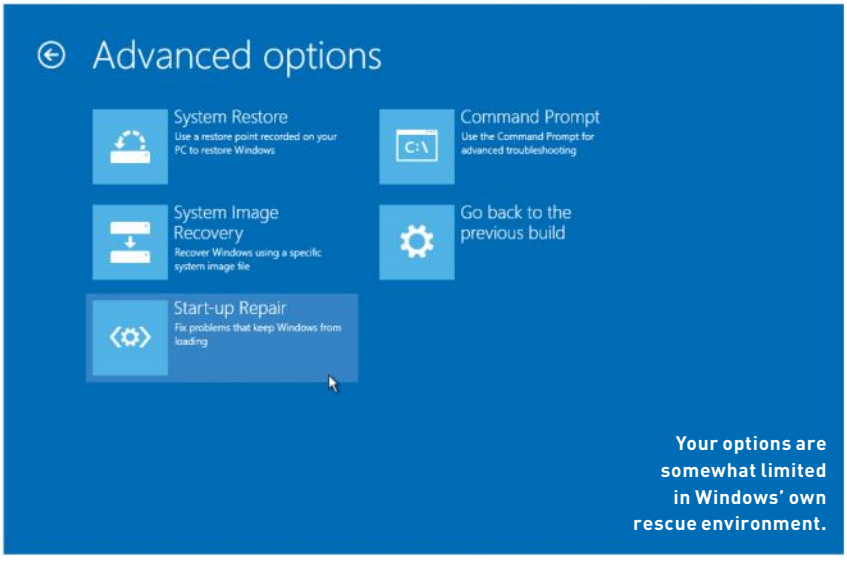
The time to create this media is right now, while your PC is still working, so turn the page, and protect yourself against disaster.

Our first recovery disc is—as it's always been—the humble Windows installation disc. Can't boot into Windows? Boot from this instead, choosing the "Repair your computer" option when prompted. From here, you can attempt to fix startup problems automatically, launch System Restore to try rolling back to a previously working installation, or even restore Windows from a disk image. Advanced users can dig deeper, with access to the command prompt, too.

These days, most of us don't bother with DVDs, so it's unlikely that you've got any installation media to hand. Let's begin, then, by rectifying that situation. Start by typing "recovery" into the Cortana search box, then choose "Create a recovery drive." You're prompted to back up system files to it, which effectively creates a full-blown reinstall disc—you need an 8GB flash drive if you go down this route. Alternatively, uncheck the "Back up system files to the recovery drive" box, and make do with the basic repair options—in which case, all you need is a 512MB USB flash drive, although you won't be able to reinstall Windows if you go down this route.

(Note: If you want to create a bootable DVD, you need the Media Creation Tool—download the latest version from www.microsoft.com/software-download/windows10, and choose the ISO option when creating media for another PC, then right-click this file, and choose "Burn disc image" to burn your disc.)

From here, if Windows fails to boot, pop in your installation disc or drive, and either make it your first bootable device in the BIOS, or look for an option to choose the boot device at startup, choosing the rescue media when prompted—note, if you're shown two options (typically "UEFI" and "USB"), choose "UEFI." From here, you can follow the prompts to hopefully bring your PC back to life, or—if all other avenues fail—reinstall Windows from scratch.


Advanced options
System Restore
Use a restore point recorded on your PC to restore Windows
Command Prompt
Use the Command Prompt for advanced troubleshooting
System Image Recovery
Recover Windows using a specific system image file
Go back to the previous build
Start-up Repair
Fix problems that keep Windows from loading

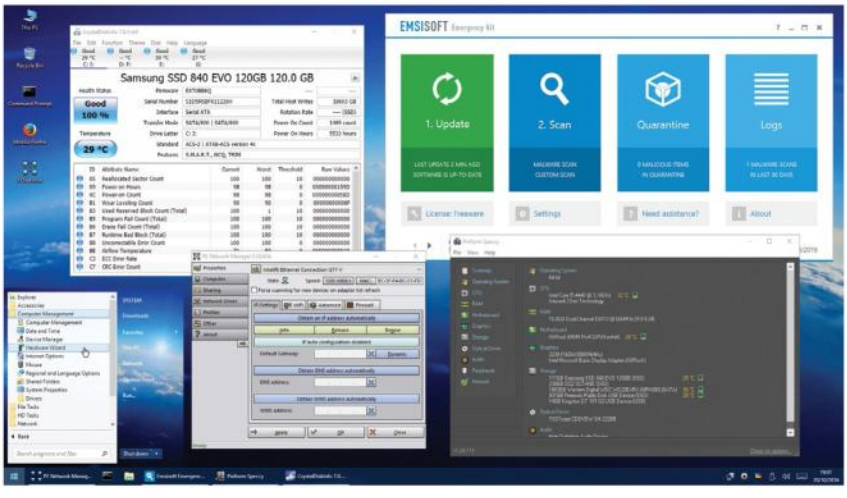
Your options are somewhat limited in Windows' own rescue environment.

BEYOND THE BASICS

The Windows repair tool is all well and good, but there are times when it can't help. It can't disinfect your malware-infested drive, for example, and neither can you easily copy files from a badly mangled Windows installation, before formatting the drive, and starting again. If you want to protect yourself against either of these two possibilities, you need to augment it with something else.

Most antimalware vendors offer a recovery disc solution that specializes in rooting out malware—see the box opposite for details about creating a fourth recovery disc if you decide against the full-blown Live CD option later on in this feature. In the meantime, our second recovery disc takes things one step further than the Windows install disc. Lazesoft Recovery Suite Home Edition is free (for non-commercial use), so start by downloading and installing it from www.lazesoft.com/lazesoft-recovery-suite-free.html.

Lazesoft Recovery Suite contains four key components, all of which can be run directly from Windows (even in Safe mode). Of course, we're interested in building recovery boot media, so after launch, click the "Burn CD/USB Disk" link. You're asked to specify the target version of Windows—leave the default "DO NOT specify" setting applied for Windows 10 support, then click "Next." Choose your target media: CD/DVD, USB, or ISO file, then click "Start." Once created, check out the box over the page to find out what sort of problems Lazesoft can attempt to fix.



Win10PESE provides you with a recovery environment based on Windows.

ONWARD AND UPWARD

Lazesoft Recovery Suite is well worth using in case it can fix your problem with just a few clicks, but what if it can't? In an ideal world, you'd be able to boot into a more complete Windows-like environment—one that employs the familiar point-and-click interface, while giving you access to a wider range of tools, full Internet access (being able to research error messages online could be a crucial step toward solving your problem), and more besides.

The good news is that all of this is possible—Microsoft produces a specialized

It can take a while to build your customized recovery disc.

version of Windows called Windows PE, with "PE" standing for "Pre-installation Environment." It's designed to be run directly from removable media, and has been adapted over the years by various individuals to provide recovery discs that can give you the best of all worlds—think Bart PE (based on Windows XP) and AOMEI PE Builder (Windows 7 or 8, but not 8.1 or 10).

One of the most successful PE-building tools is WinBuilder, and one user-friendly variant for Windows 10 comes in the form of Win10PESE. It's a flexible custom recovery tool builder that enables you to incorporate additional apps and tools if you need them, and can be burned to DVD or USB flash drive (1GB or larger).

BUILD YOUR OWN CUSTOM RECOVERY DISC

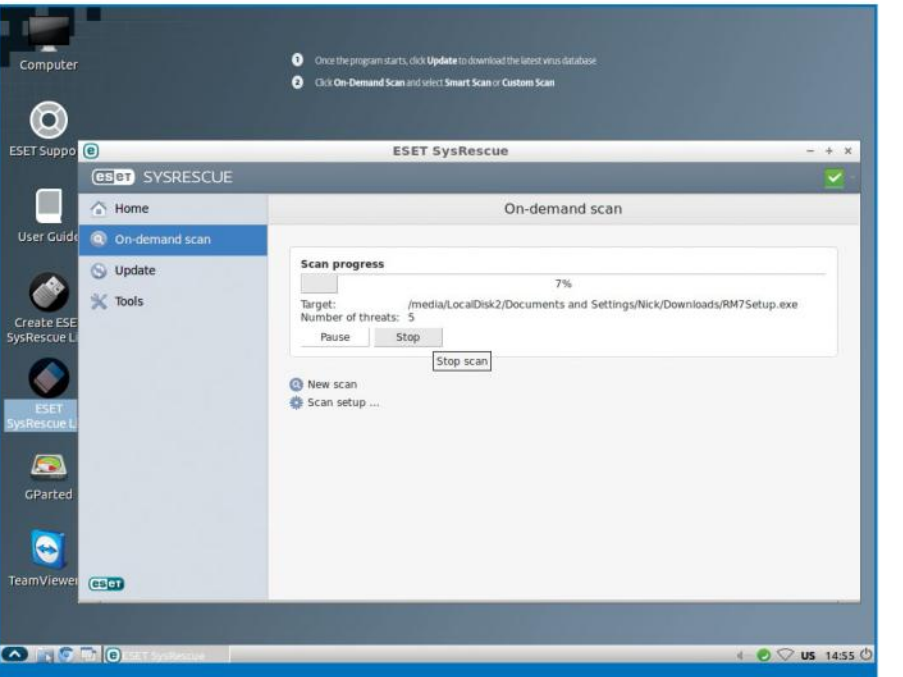
Start by visiting http://win10se.cwcodes.net/Compressed/, and click the link under the "Package" column to save the recovery builder tool in zip format to your hard drive. Once done, right-click the zip file, and choose "Extract All," then open the Win10PE_SE_<date> folder (the <date> corresponds to the latest build number), and double-click "BuilderSE.exe" to get started. The WinBuilder main screen reveals all the basic steps that you need to follow.

One of those steps involves giving the builder access to Windows 10 installation media—sadly, your recovery drive (or a disc created using the Media Creation Tool) doesn't count. Instead, click the "Microsoft Windows and Office ISO Download Tool" link in WinBuilder to access a tool that downloads the Windows 10 ISO. Once downloaded, launch the app, select "Windows 10," then choose the "Windows 10 Home/Pro" link from the drop-down menu, before clicking "Confirm." Choose your language, click "Confirm" again, then pick the 64-bit or 32-bit download, based on which version you currently have (press Windows-Pause/Break to find out if you're not sure), to download the ISO file.

Next, double-click the ISO file to allow Windows to mount it as a virtual CD/DVD drive (it'll be visible in File Explorer). Now return to Win10PESE, and click the "Source" button. Click the folder button under "Source Directory" to select the virtual disc drive.

In the program's left-hand pane, you'll see a number of collapsible folders that, when opened, revealed additional settings. If you're in a hurry, you can skip all of these to generate a basic, but usable, ISO file—just click the play button, sit back, and wait for the disc to be created. Once complete, look inside the Win10PE_SE_<date>\ISO folder for the ISO file you can subsequently burn to disc, by right-clicking the file and choosing "Burn disc image."

If you're creating a bootable USB recovery drive, however, you should take



MALWARE RECOVERY DISCS

One of malware's nastiest tricks is to cripple your PC so it's virtually impossible to clean. The malware typically suppresses known security tools from running, plus locks down your system in various ways, such as restricting which websites you can visit, barring access to Registry Editor, and even crippling Safe mode, inside which most antimalware tools can at least attempt to clean up the mess. To be fair, Windows 10 makes it hard enough to access Safe mode these days, so we're not sure why malware bothers, but we digress.

The solution here lies in visiting your security vendor's site to locate recovery media that includes a special version of your antimalware product that has network access to update itself, then focuses on detecting and cleaning malware. Depending on the tool and the infection, you should find any collateral damage has also been repaired, although tools such as Windows Repair (www.tweaking.com) and Complete Internet Repair (www.rizonesoft.com) can be used in Windows proper after the malware has been scrubbed if this doesn't prove to be the case.

These tools are completely free to use, so you don't need to be a paying purchaser of a particular package to use it. Just download the ISO file to the hard drive of a clean, working PC, then right-click it, and choose "Burn disc image" to burn a DVD from it, or use a tool such as Rufus (https://rufus.akeo.ie) to create a bootable USB flash drive from the ISO's contents, if the vendor in question doesn't provide a live CD/USB creation tool.

Major antimalware vendors offering bootable recovery discs include Kaspersky (https://support.kaspersky.co.uk/4162), Norton (https://security.symantec.com/nbrt/nbrt.aspx), ESET (www.eset.com/int/support/sysrescue), and AVG (www.avg.com/ww-en/download.prd-arl). Just Google your antimalware vendor and the words "recovery disc" or "rescue disc" to see if it's covered.

the time to expand the "WriteMedia" section. If your PC has a 64-bit UEFI (check with the manufacturer), select the "Copy to USB-Device" box; if not, select "Copy to USB-Device BCD Bootloader" instead, and check "Add Grub2-EFI (x64 UEFI only)" to ensure it boots. Click the folder button under "Please select the root directory of your USB-Device," to select the correct drive letter if necessary, then click "Copy to USB" to build your recovery drive from the ISO you just created.

TAKE IT FOR A TEST DRIVE

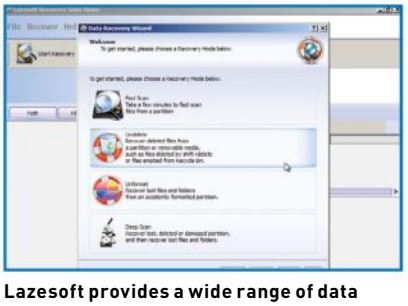
You can now test the recovery drive by booting from it in the same way you'd boot from the previous two recovery options. A menu appears—select "Win10PESE" to boot into your recovery environment. When the desktop environment pops up, you're prompted to choose your network connection type, if one is detected—the default DHCP is automatically selected after a five-second pause.

You then find yourself at a close approximation of the Windows 10 desktop, albeit one employing a more "classic" Windows look and feel. You'll see convenient shortcuts to File Explorer, the Command Prompt, and PENetwork on both the Taskbar and desktop—there's also a shortcut to Firefox, giving you access to the web. PENetwork merely launches the network manager, which should already be running and accessible from the Taskbar Notification area, alongside other controls, including one that enables you to set a different desktop resolution if you wish (note this feature doesn't work very well on UEFI systems—you're likely to find only the 1920x1080 and 1024x768 options work).

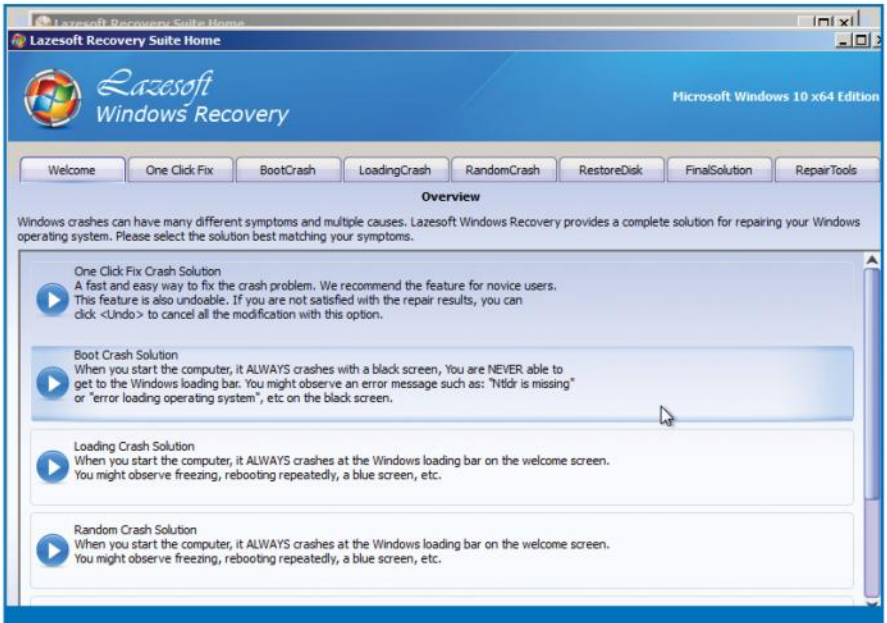
Click the "Start" button, and select "All Programs" to see what tools and utilities are included with the vanilla Win10PESE disc—shortcuts to critical Control Panel and system management applets are included, as are a handful of file-related tools (including 7-Zip), BootICE (for managing the boot manager), a PDF viewer, and some handy system tools, including Remote Regedit (for manipulating your Registry in case your boot problems stem from there), as well as access to the System Recovery options found in Windows itself.

These tools are all welcome and helpful, but you may be hankering after different tools and utilities—you may even simply want to be able to run a particular app, such as a word processor, while you try to fix your boot problem. The good news is that your Win10PESE environment can support third-party applications and programs, too.

We say "some" because, while certain program installers work, on the whole you're limited to portable apps, namely those that run directly from a folder. You can download these from the Internet (look under X:\Users\Default for the Downloads folder), but be sure to copy portable apps and key files to another drive if you want to keep them for another session—the "X" drive resides only in memory, which means it's wiped the moment you reboot.



Lazesoft provides a wide range of data recovery tools.


Lazesoft Recovery Suite Home
Lazesoft Windows Recovery
Microsoft Windows 10 x64 Edition
Welcome
One Click Fix
BootCrash
LoadingCrash
RandomCrash
RestoreDisk
FinalSolution
RepairTools
Overview
Windows crashes can have many different symptoms and multiple causes. Lazesoft Windows Recovery provides a complete solution for repairing your Windows operating system. Please select the solution best matching your symptoms.
One Click Fix Crash Solution
A fast and easy way to fix the crash problem. We recommend the feature for novice users.
This feature is also undoable. If you are not satisfied with the repair results, you can click <Undo> to cancel all the modification with this option.
Boot Crash Solution
When you start the computer, it ALWAYS crashes with a black screen, You are NEVER able to get to the Windows loading bar. You might observe an error message such as: "Ntldr is missing" or "error loading operating system", etc on the black screen.
Loading Crash Solution
When you start the computer, it ALWAYS crashes at the Windows loading bar on the welcome screen. You might observe freezing, rebooting repeatedly, a blue screen, etc.
Random Crash Solution
When you start the computer, it ALWAYS crashes at the Windows loading bar on the welcome screen. You might observe freezing, rebooting repeatedly, a blue screen, etc.

FIX WINDOWS BOOT PROBLEMS

Lazesoft Recovery Suite offers a number of handy tools for fixing problems with Windows, plus it can help you recover data, too. Once created, reboot your PC from the Lazesoft rescue media. You'll eventually find yourself at the main Lazesoft Recovery Suite, with four recovery-based options: "Windows Recovery," "Data Recovery," "Disk Image & Clone," and "Password Recovery."

All four options are largely self-explanatory. Before running any recovery tools, we recommend taking a drive image of your current setup, which ensures you can always roll things back should the cure prove worse than the malady. Select "Disk Image & Clone," and choose "Drive to Image" to back up to a suitable external drive. Second, "Data Recovery" contains the full range of data recovery options, including simply pulling off regular files, as well as searching for lost and deleted files and partitions.

"Windows Recovery" attempts to fix your boot problems, offering a wide range of options across a series of tabs. There's also a one-click solution if you'd prefer the software to try to diagnose and repair on its own, with an "Undo" button that promises to reverse any changes made if the problem isn't fixed or gets worse.

If this fails, try the other options: "BootCrash," "LoadingCrash," and "RandomCrash." Each one steps you through a series of potential fixes to try, from repairing the MBR and restoring missing or corrupted files, such as Ntosknl.exe ("BootCrash"), to running memory diagnostics, and recovering the Registry ("RandomCrash").

The final tool—"Password Recovery"—promises to reset your Windows password if you've forgotten it, plus can reveal your Windows and Office product keys, should you need them. The former option only works with local passwords—in other words, if you sign in to Windows using your Microsoft Account, you need to visit https://account.live.com/password/reset to try to fix the problem.

Win10PESE enables you to run portable apps from other drives.

BRING YOUR OWN

Luckily, you have a number of options should you wish to build up a more permanent collection of tools and utilities. Portable apps can be stored on another drive—a USB flash drive, say, or shared network folder. Access them via the Windows PE environment when needed.

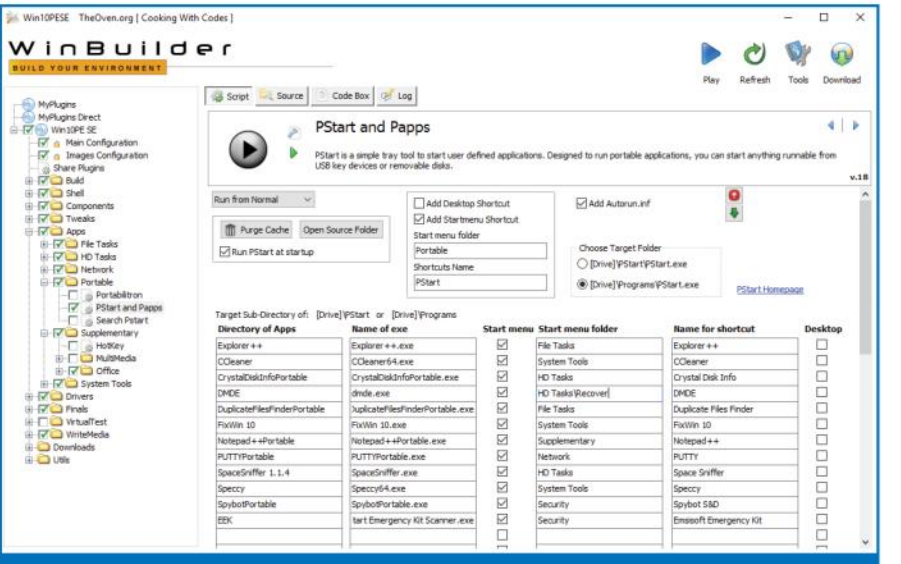
A more elegant solution, and one that incorporates your applications directly into your recovery drive (with shortcuts through the Start menu), is to follow the "Add apps to your drive" box on the right. Also take the time to explore some of the other options that Win10PESE provides. Explore the various sections of the disk-creation tool; expand "Shell," for example, and you can change the packaged Start menu, plus configure its appearance. Expand "Components," and you can choose which Windows tools and accessories to include—add the .NET Framework to support a wider range of applications, for example.

If you have a virtual Windows machine to hand using a tool such as VirtualBox (www.virtualbox.org), use it to test your recovery disc—open "VirtualTest," and select "VirtualBox Emulation" to set up a dedicated virtual machine to test the ISO file with. It's a great way to check to see what effect your tweaks have, without having to recreate a USB flash drive or boot from your PC each time. But do remember to test the final disc or drive on your actual PC when you've got it working to your satisfaction, to make sure.

TROUBLE-SHOOT YOUR PC

Your recovery discs have been created, waiting for the time they'll be needed. Now your PC is refusing to boot, and you've whisked out your recovery discs. What to do? First, we recommend taking a drive image of the system partitions before you start attempting to fix things. Use Lazesoft for this task, unless you have an emergency boot disc coupled to your existing system imaging tool (such as Macrium Reflect Free), in which case use that.

With the drive image in place, you can start to attempt a fix for your problem. Begin with your Windows installation disc, to see if its Automatic Repair tool can get Windows up and running again. Make a careful note of any error messages if the problem persists, then move on to Lazesoft's Windows Recovery component (see the box on the previous page). If Lazesoft's fix-it tools fail to fix your loading problems, bring out the Win10PESE disc. Boot from this, then use the tools onboard—such as Remote Regedit—to try to fix known problems. Don't forget your Internet connection—use Firefox to browse for possible solutions to error messages, plus download additional software you might need, but didn't include on the disc. This is particularly handy if you're battling malware infections—you can track down specific removal tools, or locate your vendor's portable scanning toolkit, should our other suggestions fail to yield results.



ADD APPS TO YOUR DRIVE

Why plug in another USB drive, or download tools from the net, when you can embed any portable tool directly into your recovery drive? Once embedded, the tools can be directly accessed through Win10PESE's Start menu, or via an icon in the Taskbar Notification area.

To add apps to your drive, first expand the "Apps → Portable" section in Win10PESE's left-hand pane, then check "PStart and Papps." Next, click the "Open Source Folder" button to open the folder where your portable apps need to be collected, each one inside its own folder. Once you've copied them into here, return to Win10PESE, and carefully enter the folder name of each app under "Directory of Apps," plus the name of the program's executable file under "Name of exe."

To add a shortcut to the Start menu, check "Start menu," and then specify the folder (get this from Projects\Win10PESE\Apps), and shortcut name; you can add a desktop shortcut, too, by checking the appropriate box. Finally, if you're burning a DVD, rather than creating a USB recovery drive, be sure to select "Run from RAM" to allow any antimalware tools to download and process updates. Then create the disc in the usual way.

What sort of portable apps should you be looking to add to your toolkit? Two recommended antimalware tools are Emsisoft Emergency Kit (www.emsisoft.com/en/software/eek), which utilizes two antimalware engines, and Malwarebytes Junkware Removal Tool (www.malwarebytes.com/junkwareremovaltool) for PUPs.

Piriform (www.piriform.com) provides portable versions of CCleaner (cleanup tool), Recuva (data recovery), and Speccy (system information). Another data recovery tool worth adding is DMDE Free (https://dmde.com), while a wide array of tools, from alternative browsers, to disk encryption, to drive health monitoring utilities, can be found at www.portableapps.com.

Finally, if there's a specific utility you want, check with the vendor's website—often, you can find portable builds buried away in the downloads section.

THIS IS A RAID

It's out of the clean rooms and into our homes, but should you be running RAID? And if so, which type? *By Chris Lloyd*

In 1980, IBM's 3380 hard drive cost $81,000 for the 2.5GB model. For the same money, you could walk into your local GM dealer, and buy five Cadillac Eldorados. The huge cost of high-speed storage provided the impetus to develop something that could match these monsters for less—enter the Redundant Array of Inexpensive Disks, RAID's original acronym.

The idea was simple: couple together a number of smaller and cheaper drives to build a larger, faster, and more reliable unit. Data is spread across the disks to introduce a level of redundancy. The concept and the odd patent was knocking about in the '70s, but the first hardware didn't arrive until 1983 (a simple mirrored system from DEC). The term RAID wasn't coined until 1987, and it wasn't until the 1990s that it found favor and started to be used in earnest, before becoming the staple of server rooms. The early systems didn't prove as inexpensive as hoped, either, so the acronym was quietly changed from "Inexpensive" to "Independent."

Hard drives have now become much, much cheaper, and adding RAID to your home rig is well within reach. You'll find software support in Windows and Linux, along with basic hardware support built into most half-decent motherboards. The cost can range from next to nothing, if you have a couple of old drives on the shelf, to $1,000 and upward, if you're after some serious storage. The first question to ask yourself is: Is it worth it? Quickly followed by: What sort of RAID should you employ?

RAID comes in various numbered levels, standardized by the Storage Networking Industry Association. These define the way the data is stored across the disks. Each level has its strengths and weaknesses. So, let's introduce the main contenders currently in widespread use.

RAID Level 0

Data is striped across drives—blocks of data are written in parallel on two or more disks. These disks need to be the same size, although unused space can be used elsewhere with some clever partitioning. As with all levels, the RAID array appears as a single volume. This level is built for speed; in practice, on a typical setup, a two-disk RAID 0 gives you about a 50 percent increase in raw data transfer rates, although access times remain about the same. The size of each data block—the stripe size—affects performance. Options range from 4KB to 128KB. Generally, the larger, the faster, although it increases potential wastage. A smaller stripe size can lead to gains if you have a larger number of disks, or small files. By and large, a compromise somewhere in the middle is best. Adding more disks makes the array faster incrementally, in theory. However, there's a number of other factors that come into play with bandwidth limits and bottlenecks elsewhere in your system, so expect diminishing returns. RAID 0 has no parity or redundancy—if a disk dies, the whole thing is fried, and the more disks you use, the greater that risk. If you place performance above all else, then RAID 0 delivers it simply.

RAID Level 1

This level uses mirroring. Blocks of data are copied to multiple disks at once—generally two, unless you really do expect to be unlucky. These need to be of equal size, and overall capacity is halved. If a drive fails, then you've still got a full copy of the data. So, after you've replaced the failed drive, and copied across the data, you are back to where you started. You can continue to use the array even with one drive down. Performance is pretty much the same as for a single drive, despite any theoretical gains. Read speeds can be increased, but this is down to how the controller and OS work; Windows can struggle to see much difference. RAID 1 is really aimed at data safety done simply.

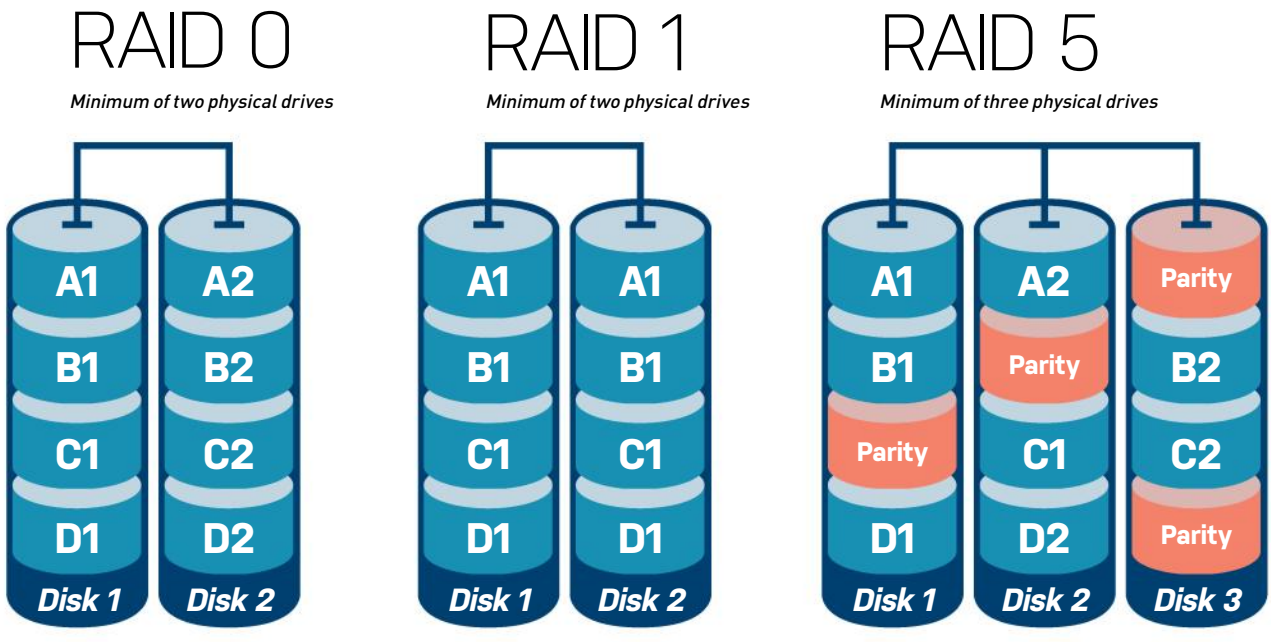
RAID Level 5

Now it starts to get a little more complicated. This level uses striping, as Level 0, but adds distributed parity into the mix, to allow for a disk failure. Data blocks are striped as RAID 0, and a block of parity data is calculated and written on a separate physical drive. You need a minimum of three disks, and you effectively lose one drive to the parity data. The parity blocks are distributed across the physical drives. If a drive fails, then the data can be rebuilt from the data and parity data. It's worth noting that this is far from quick—it can easily take hours or even days to rebuild an array with modern drives. You still have access to your data, even with one drive down. Data read speeds are good, but the need to calculate the parity drags down write speeds. RAID 5 is a compromise between security and performance. Capacity reduction is less than for a straight mirrored system, and read speeds are better. It doesn't work well with a large number of small random write operations, however. This level used to be recommended for applications where data security was paramount, but times have changed. More on that later.

IBM's 3380 hard drive: an engineering masterpiece, and the size of a refrigerator.

RAID Level 6

Much like RAID 5, but with double parity. It requires a minimum of four drives. Data is striped to two drives, then the parity data is written to the remaining two drives. No matter how many drives you have, two are effectively lost to parity data. Like RAID 5, the read speeds are good, but write speeds are compromised. The big advantage over RAID 5 is that a RAID 6 system can recover from the loss of two drives at once. You have access to the data, even while a failed drive is being rebuilt, which, like RAID 5, can be



The good old days.
Capacities and prices like this prompted the development of RAID systems.

painfully slow. It's the RAID of choice for any system that needs to be up and running at all times, because drives can be swapped out while it's still operating.

RAID Level 10

Also known as RAID 1+0. A nested array, it's effectively a combination of striping and mirroring. It requires a minimum of four drives, divided into two groups. Data is striped across the groups, and mirrored within the group. Capacity is always halved, no matter how many drives you add. RAID 10 can survive the loss of one drive, and without the need to rebuild from parity data, rebuild times are good. A second failure is not always fatal—if it's the mirror of the first failed drive. RAID 10 offers the advantages of RAID 0 speeds, and improved security over RAID 1. It is good with large files and streaming. The biggest drawback is the loss of half the capacity however many drives you add.

More RAIDs

That's not all. There are dozens of non-standard and proprietary levels of RAID. These include other nested variations, such as RAID 5+0 and 1+0+0, and versions limited to certain OSes, filesystems, or specific hardware. However, they are all pretty much variations of the existing levels. RAID 60, for example, stripes data across two RAID 6 groups. It increases performance due to striping, and doubles the number of disks you can lose before a full data loss. However, you need a minimum of eight disks, and you lose half the capacity to parity data. There is also an interesting non-standard array called RAID-1E, which combines mirroring and striping, making a copy of each data block, useful for a three-drive array.

WHICH DO I WANT?

If speed is your thing, RAID 0 is the fastest. Others may come close, but for consistent maximum performance, it is the best. You also get to use all the drive capacity you've bought. The downside is the increased risk. Any unrecoverable sector is just that: gone for good. If any drive in the array fails, you've lost everything—time to format, and start again. The more disks in the array, the higher the chance. It does come into its own when used for very large temporary files, such as those created by image and video editors. You can run these from a fast RAID 0 array safely, because any data loss is easily reconstructed. However, given the

The RAID Levels that Time Forgot

RAID 2 This stripes data across multiple drives, but instead of blocks of data, it stripes at the bit level, complete with Hamming code error correction. High data rates are possible, but it's complex, and requires large arrays of synchronized spinning disks. Now, hard drives have much of the error correction built in, making RAID 2 pretty much redundant.

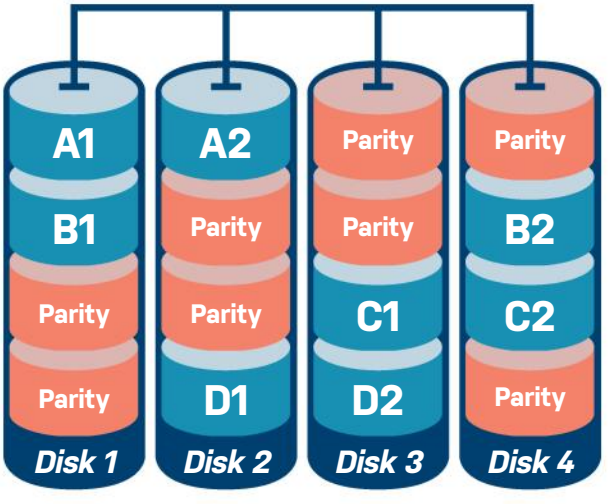
RAID 3 This stripes bits as RAID 2, and writes parity data to a dedicated parity disk. It proved to be not as reliable or cheap as other systems, the single parity disk being a major bottleneck.

RAID 4 Similar to RAID 5, this stripes data at block level, but still puts all the parity on one disk. The large capacities of modern drives mean rebuilding the parity disk after a failure is a long, long job. Best to stick to the distributed parity used in RAID 5 and 6.

RAID 7 A proprietary level of the now defunct Storage Computer Corporation. It turned out to be a variation on RAID 4 with a cache. After unsuccessful attempts to enforce spurious patents on the makers of other parity RAID systems, it all collapsed around the year 2000.

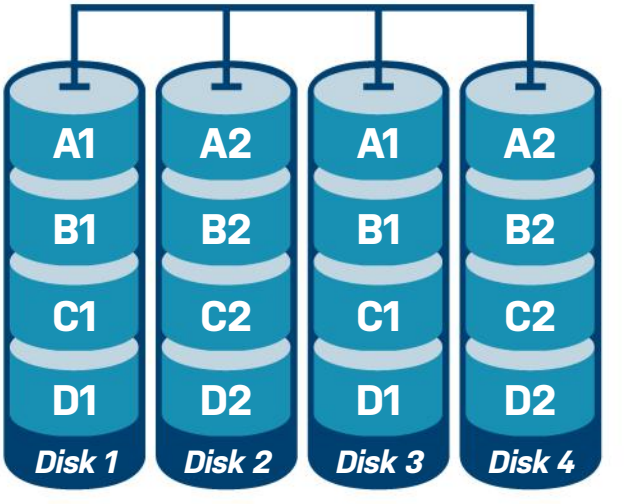
RAID 6

Minimum of four physical drives



RAID 10

Minimum of four physical drives



Non-RAID Options

Sure you want RAID? If it's just speed you're after, a single, large SSD is a better investment. No hard drive RAID 0 system will even get close. Of course, you could always add SSDs to your RAID 0, and go nuts, although SATA 3 limits the fun, unless you move to PCIe-based controllers, including the lovely M.2. True maniacs can go RAID 0 across M.2 slots, making read speeds of 3,000MB/s-plus possible. However, for sheer speed, add SSDs to your existing controllers first.

If you just want to use a motley collection of hard drives more effectively, JBOD—Just a Bunch of Disks—might be a better bet than RAID. There's no redundancy or performance increase, but no capacity loss, either. Your drives are arranged into one logical drive. All you need is a cheap compatible controller card ($30 is plenty). If you simply need more storage, it's cheaper, and can use up mismatched drives. However, if a drive fails, you're in the hands of data recovery tools, because the whole lot goes down.

If data security is paramount, then yes, RAID 6 offers it. However, it is no replacement for a proper backup routine. RAID offers good protection if a drive fails in action, and nothing more. It won't save you from a hack, virus, theft, fire, power spike, or accidental deletion. If you can cope with recovering the data from your last backup after a failure, there's no urgent need for RAID—just get another drive, preferably an external one, make regular backups, and leave it at that.

performance of modern SSDs, you are far better off investing in these first, rather than a RAID of spinners, unless you really need the capacity.

RAID 0 too risky? RAID 1 offers simple redundancy, but capacity is halved, and performance gains minimal. If a drive's mirror fails during a rebuild, it's dead. However, RAID 1 is nice and simple, and you only need two drives. If security is important, you can do better. RAID 5 used to be the default choice, but things have moved on. RAID 5 can recover from a drive failure, but it has become increasingly vulnerable to multiple failures.

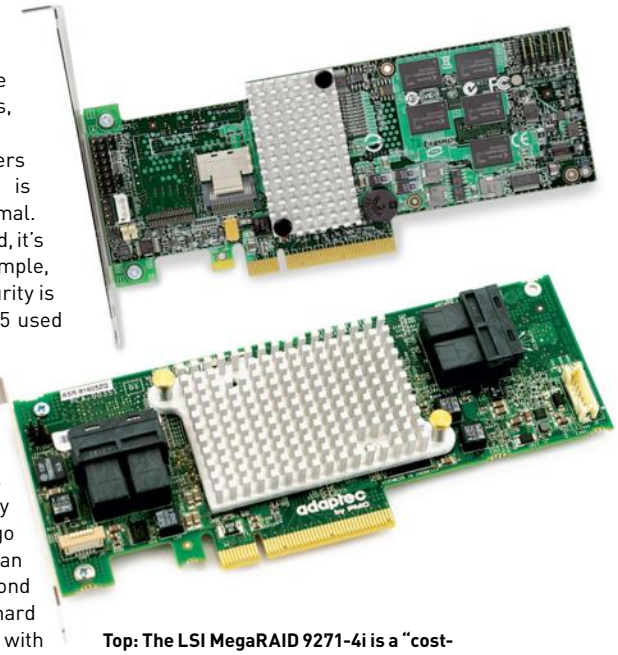
For good data security, RAID 6 is preferable. That extra redundancy means you can have a drive go down, and it can still survive an unrecoverable data loss on a second drive. Sounds unlikely? Modern hard drives are reliable beasts, but even with a tiny chance of error on any one bit, the cumulative effect makes even a slim chance a real risk when spread over multiple large disks. A typical drive has an Unrecoverable Read Error of 10 to the power of 14; the best can even manage 15. Plug that tiny number into some math, and your chances of failure with a multi-terabyte RAID 5 starts to enter single-digit percentages. RAID 5 no longer offers the levels of security it was designed to give, and can't be recommended. RAID 6 means the loss of a drive to parity data—but think about how catastrophic full data loss would be. Given current drive prices, it's worth losing the capacity to be safe.

That said, RAID 6 is due to hit the same problems as RAID 5 in a few years' time, given the rate at which drives are getting bigger. Triple-parity RAID isn't far away now, although rebuild and data scrubbing times may make it cumbersome in practice. We could soon see the end of traditional parity-based redundancy.

That leaves us with RAID 10, which combines the best bit of RAID 0, the speed, with the best bit of RAID 1, the redundancy. It lacks the data security of parity checking, but is a good compromise between safety and speed. You do lose half the capacity, though. Which do you want? It depends on what you need, but if security is key, it has to be RAID 6. Apart from specialist applications, RAID 10 looks good—drives are cheap enough to stomach the capacity loss for the extra security and speed.

THE HARDWARE

A full-on RAID controller includes a dedicated processor, called ROC (RAID-on-Chip), cache memory, and more. Many consumer motherboards have RAID support, but the abilities and quality vary,



Top: The LSI MegaRAID 9271-4i is a "cost-effective" hardware RAID card.
Below: The Adaptec 71605 is aimed at entry-level servers, and costs around $750.

because they lack the dedicated hardware, pushing RAID functions over to the rest of the board, the processor, and software. You'll find the motherboard is limited in some ways, only supporting RAID 0, 1, and 5, using whole drives only, no support for hotswapping, and more. Disparagingly called "Fake RAID" by the denizens of server rooms, they are usually much more inflexible than software RAID, without the benefits of a full hardware implementation.

If you're thinking of using your motherboard's controller, read the specifications carefully. These simpler hardware controllers work well enough in a home rig, but it's worth knowing the limitations before you start. If you are going for the security of RAID 6, a more capable controller needs to be in your budget. It can get confusing working out exactly how capable a hardware RAID is, but the price of a controller should be a big clue. If it's tens of dollars, it isn't a full hardware implementation. A "proper" PCIe hardware RAID controller can run into the hundreds.

Running RAID in software sounds like it'll compromise performance, but processors are fast enough now, and if you run without parity, a software RAID can be light on CPU load. Depending on your OS, they can be very flexible, too—Linux take a bow.

SATA or SAS? Depending on your controller, you'll have a choice. Mixing types is frowned upon. SAS drives are sold as "enterprise" drives, and are technically more competent, and theoretically faster. However, benefiting from the extra performance would mean building a

Seriously, you've got it easy nowadays.

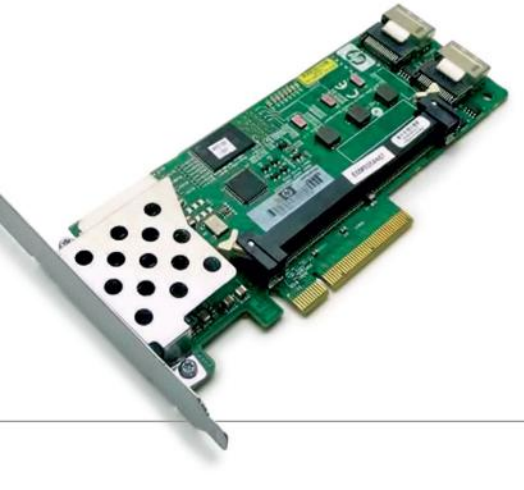
serious hardware RAID. SAS drives come in at around $100 for 1TB. Best to go SATA, where $50 buys you 1TB, and $150 gets you 5TB. Don't forget to budget for an enclosure and cables if you plan on a large RAID.

Full hardware RAID systems expect TLER hard drives: Time Limited Error Recovery. If a drive encounters a problem—reallocating a bad block, for example—it can take a few seconds or longer to resolve. However, your RAID controller is likely to notice earlier, and mark the whole drive as having failed. TLER drives take seven seconds to try to fix the problem, then send a warning message to the controller, and defer further attempts. It enables the controller and drive to co-operate more effectively to repair problems. Without it, you might replace good disks needlessly. If the drive has the word "Enterprise" in its name, TLER is enabled. Otherwise, you have to check it's compatible, and turn it on in firmware. If you're running a software or simple hardware RAID, you don't have to worry about TLER.

A simple rule of thumb is to use as many drives as possible. Due to the parallel nature of RAID, the more drives you have, the faster it is. If you are using parity, more drives mean that rebuild times are shorter, as each drive holds less of the parity data. The situation for SSDs is reversed, as the higher capacity drives are faster; although, again, it's worth checking the specifications.

If a drive does go down, you'll probably want a replacement quickly. Best to be prepared, and have an extra drive ready and waiting. Remember: RAID really wants matched drives—not just the same capacity, but identical ones. If you don't have one ready, you might have to compromise, or spend time looking for a decent match.

The HP 462919 offers capabilities comparable to most consumer motherboards.



SHOULD YOU?

Many RAID systems can recover from the loss of a disk; some more than one. Don't let this beguile you into thinking it's a safe place for important data. It isn't a substitute for a proper backup. A power spike can still kill the whole rack. And you have no incremental backup, so if you overwrite an important file, it's gone as effectively as on a failed drive. You're still putting all your eggs in one basket, albeit a more robust one. You still need an effective backup.

Just because you can, it doesn't follow that you should. Hardware RAID can get expensive and complicated fairly quickly. This is a technology that has come down from the server rooms, and can be daunting. Think what you want to achieve and why; RAID might not be the answer. In its simplest form—using Windows 10 Storage Spaces to configure a couple of drives, for example—it is painless enough, but from then on, it can get tricky fast. It's no magic bullet, either—there's no such thing as completely secure storage or fault-free operation. Still interested? Good. Done right, the performance can be intoxicating. Just don't get carried away.

The Future of RAID

RAID is getting old. As drives get bigger, it struggles to cope. Rebuild times using parity can run into days, and reliability is falling. Really big operations, such as Google, Facebook, and Microsoft, have already moved away from RAID.

There are two approaches to improve things: to build on existing RAID levels, adding triple parity, for example, or to get clever with the math. Enter Rateless Erasure Coding. This uses mathematical functions to define a block of data as a potentially limitless sequence. The math is fiendish, but means your original data can be reconstructed from any subset of the translation equal to or slightly larger than the original—effectively, all the data becomes parity data. You can practically pick your level of redundancy. Want it secure after four failures, or more? It can be done, as can fast repairs after any loss. It's early days, but it is promising. Microsoft uses a version of Erasure Coding in its massive Azure data centers.

More immediately pertinent for home use is the development of new file systems, which have RAID levels of data security and the flexible use of drives built in, rather than added on top.

ZFS (Zettabyte File System), originally from Sun, but now open source, includes many RAID functions, including using checksums, copy-on-write, dynamic striping, and more. It's readily available on Linux systems. Btrfs (B-tree file system), from Oracle, is also available for Linux, and uses copy-on-write at its core. BeyondRAID, from Drobo, offers benefits for a NAS box, although it is proprietary.

Of most interest is Microsoft's ReFS (Resilient File System). It's in Windows Server 2012. It will replace NTFS at some point, though it could be years before it's the Windows standard. It brings many features of RAID right into the filesystem, with integrity checking, copy-on-write, metadata scrubbing, and more. Microsoft boasts that it offers hardware RAID levels of speed and data resiliency, and it has proved pretty capable on Server 2012. You can try it under Win 10 if you use Storage Space to create mirrored drives. So far, though, you can't use it on your boot drive.

Will these kill dedicated hardware RAID? It's doubtful—there will always be a need for ultra-reliable specialist storage, because some data will always be too important to lose, and some servers too important to go down.

Windows 10

CyberPowerPC recommends Windows.
One experience for everything in your life.

Gamer Extreme XT

Windows 10 Home

Intel® Core™ i7-6800K Processor

GIGABYTE® X99 Chipset Mainboard
16GB DDR4 3000MHz Quad Ch. Memory
240GB SSD + 2TB SATA III 6.0 HDD 7200RPM
NVIDIA® GeForce® GTX 1070 8GB Video Card
Cyberpower Aula Gaming Headset
In Win 303 Gaming Case + 600W 80+ PSU
Asetek Liquid Cooling System

HD 7.1 600W | Cyberpower | Cyberpower

FROM **$1599**

Liquid Cooling **FREE**

VECTOR II 15-VR 600

15.6"HD

FROM **$1129**

Windows 10 Home

Intel® Core™ i7-7700HQ Processor

Intel® HM170 Express Chipset
15.6" FHD IPS Non-Reflective 1920 x 1080
NVIDIA® GeForce® GTX 1060 6GB
240GB Z410 SATA Solid State Drive
RGB Programmable Gaming Keyboard
8GB DDR4/2133MHz Memory
Gigabit LAN, HDMI 2.0m, MiniDP

DVD	250 Mins	Bluetooth 4.0	1x USB 3.0 1x 3.1 Type C
8X DVD ±RW			
HDMI 1.4	HD 30FPS Webcam	Mini-DP 1.2	5.29 Lbs.

VECTOR II 15-VR 800

17.3"HD

FROM **$1235**

Windows 10 Home

Intel® Core™ i7-7700HQ Processor

Intel® HM170 Express Chipset
15.6" FHD IPS Non-Reflective 1920 x 1080
NVIDIA® GeForce® GTX 1060 6GB
480GB Z410 SATA Solid State Drive
RGB Programmable Gaming Keyboard
8GB DDR4/2133MHz Memory
Gigabit LAN, HDMI 2.0m, MiniDP
Intel® 802.11 AC Wireless + BT V4.2

DVD	250 Mins	Bluetooth 4.0	1x USB 3.0 1x 3.1 Type C
8X DVD ±RW			
HDMI 1.4	HD 30FPS Webcam	Mini-DP 1.2	5.95 Lbs.

CYBERPOWERPC
UNLEASH THE POWER

ORDER TODAY! **800.707.0393**
www.cyberpowerpc.com

Cortana available in select markets at launch, experience may vary by device.
*External monitor must support HDMI input (If continuum-compatible accessory is not included, add: *Accessories sold seperately.*) **App availability and experience varies by device and market. Office 365 subscription required for some features. 1Limited to select premium phones at launch. Feature and app availability and experience may vary by market and device. Windows Hello required specialized hardware, including fingerprint reader, illuminated IR sensor or other biometric sensors.

Work easy. Play hard. Windows

Intel Inside®. Amazing Experience Outside.

FREE LIQUID COOLING

CPUs with standard fansinks can reach core temperatures as high as 130°C, however, liquid cooling can lower that to 59°C giving you better performance and longer lifespan on your CPU.

$54.99 VALUE

Gamer Xtreme 2000

Windows 10 Home
Intel® Core™ i3-7300K Processor
GIGABYTE® Z270 Chipset Mainboard (USB 3.1)
Corsair® 8GB DDR4 3000MHz Dual Ch. Memory
1TB SATA III HDD 7200RPM
NVIDIA® GeForce® GTX 1050TI 4GB Video Card
Cyberpower Aula Gaming Headset
Phanteks Eclipse P400 with tempered glass Gaming Case + 600W PSU
Asetek Liquid Cooling System

Liquid Cooling FREE

FROM $799

HD 7.1 | Cyberpower | Cyberpower

Gamer Xtreme 3000

Windows 10 Home
Intel® Core™ i7-7700K Processor
GIGABYTE® Z270 Chipset Mainboard (USB 3.1)
Corsair® 16GB DDR4 3000MHz Dual Ch. Memory
240GB SATA III SSD Boot Drive
2TB SATA III 6.0 HDD 7200RPM
NVIDIA® GeForce® GTX 1070 8GB Video Card
CyberpowerPC Aula Gaming Headset
Phanteks Enthoo Pro M Gaming Case + 600W 80+ PSU
Asetek Liquid Cooling System

Liquid Cooling FREE

FROM $1469

14x Optical Drive | HD 7.1 | Cyberpower | Cyberpower

Gamer Infinity 8800 Pro SE

Windows 10 Home
Intel® Core™ i7-6800K Processor
GIGABYTE® X99 Chipset Mainboard
Corsair® 32GB DDR4 3000MHz Quad Ch. Memory
240GB SATA III SSD Boot Drive
3TB SATA II Data Hard Drive
NVIDIA® GeForce® GTX 1080 8GB Video Card
CyberpowerPC Aula Gaming Headset
NZXT H440 Design by Razer Gaming Case + 600W 80+ PSU
Asetek Liquid Cooling System

Liquid Cooling FREE

FROM $1999

14x Optical Drive | HD 7.1 | Cyberpower | Cyberpower

Syber M Pro 200

Windows 10 Home
Intel® Core™ i5-7600K Processor
GIGABYTE® Z270 Chipset Mainboard with UBS 3.1
CORSAIR® 16GB DDR4 3000Mhz Dual Ch. Memory
240GB SSD + 2TB SATA-III 3.0 HDD 7200 RPM
NVIDIA® GeForce® GTX 1060 3GB Video Card
Cyberpower Aula Gaming Headset
Syber M Series Gaming Case 600W 80+ PSU

FROM $999

24X DVD ±RW | HD 7.1 600W | Cyberpower | Cyberpower

Order your ultimate gaming system today! **www.cyberpowerpc.com**

730 Baldwin Park Blvd., City of Industry, CA 91746

All Desktop systems come with 3 year Limited Warranty + lifetime toll free techsupport

CyberPowerPC, CyberPowerPC Logo and, Unleash The Power are trademarks of CyberPower Inc. Copyright © 2013 CyberPower. All rights reserved. All prices are subject to change without notice or obligation. Celeron, Celeron Inside, Centrino Inside, Centrino Logo, Core Inside, Intel, Intel Logo, Intel Core, Intel Inside, Intel Inside Logo, Intel Viiv, Intel vPro, Itanium, Itanium Inside, Pentium, Pentium Inside, Viiv Inside, vPro Inside, Xeon, and Xeon Inside are trademarks of Intel Corporation in the U.S. and other countries. All prices are subject to change without notice or obligation. CyberPower is not responsible for any typographical or photographic errors. NVIDIA®, nForce®, GeForce®, SLITM are trademarks or registered trademarks of NVIDIA Corporation or its subsidiaries in the United States and other countries. CyberPower PCs use genuine Microsoft® Windows®, www.microsoft.com/piracy/howtotell

TAKE FULL CONTROL OF ALL YOUR APPS

Take control of your apps and you take control of your PC. *Alex Cox* explains all you need to know about managing your installed content

Applications—programs you run on your PC—are a constant. They're always there. We all use them, and our machines would be dusty husks without them. But they do have a tendency to get a bit out of control, particularly if a system has existed for a long time. An application almost always consists of a bunch of files; the more apps and games you have installed, the more files exist on your hard drive. This isn't, in itself, a problem, until your drive is filled with ten thousand chunks of goodness-knows-what, and a single search operation takes half an hour because Windows has decided it must meticulously inspect every single thing. And here's a quiz for you: What was the last program you installed, and where is it on your hard drive? We'd wager that, in the first count, you're probably not sure, and in the second, you hammered through the process, let it ensconce itself in goodness-knows-what folder, and have absolutely no idea what other things it scattered over your hard disk.

Going with the flow of program installation is normal and entirely understandable, but it's not difficult or onerous to get yourself organized, and a well-sorted PC will stand you in good stead for continued use. Unless you use extreme methods, you won't ever be able to stop the miasma of random files seeping through your PC. But we'll show you how to seek them out, and how to remove unwanted programs entirely. We'll even show you new ways of installing software that make it easier to manage, update, and uninstall when you're ready. And if the thought of installing software is giving you some form of filesystem OCD, we can teach you how to make your own portable apps that don't need installing in the first place, or how to integrate your favorite apps into a custom build of Windows 10 that starts a clean PC exactly the way you want it.

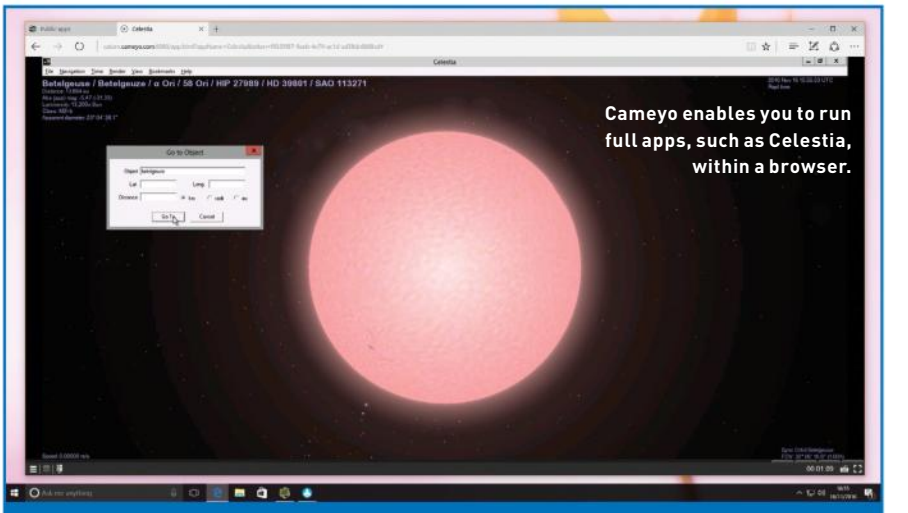
WHAT IS INSTALLING?

Once upon a time—and we're going back some 20 years here—getting a program up and running involved little more than placing a few files in a folder on your PC. That's all an installer did. Don't have the right drivers? Tough luck. Find them yourself. Operating system not up to scratch? Go through all the hassle first, and you'll find out that something's wrong when you try to run your application. A dark time, but one with benefits: Removing a program folder meant, usually, erasing all trace of that software. A simple scheme from a time when, however bleak things might have been, operating systems were less complex, and software depended on little.

Try manually excising a bit of software now, and you'll not have a good time; the typical modern installer is responsible for more tasks, and spreads the software much wider, and uninstallers are required to scrape off the remains of redundant apps. The installer decompresses large files, which have been archived to ensure an efficient distribution size. It determines whether you're installing from scratch or upgrading. It places references to program variables in the Windows registry, and configures other files to suit your hardware and personal preferences. It downloads, or upgrades, software dependencies—drivers and software frameworks that the program being installed may depend upon to run. And it does even more besides.

To make things even more complex, there's not one kind of installation package, though this won't make a huge difference to the average user. You most regularly come across executables (exe files), which tend to use some kind of third-party program to get the job done, or Microsoft Installer (msi) files, which do the same thing using Windows' built-in installation components. Others—the likes of .cub, .msp, and .msm—also use the Windows Installer, and are meant for patching or modifying components. You don't see them often while using Windows on the desktop, if at all, although those who stray into server territory might get more familiar.

For all we've said, a complex installation method isn't strictly required for every app. Many apps have been designed to run in a so-called "portable" configuration, where their content is contained in a single folder and requires no installation whatsoever. While these are few and far between—portable apps are usually small tools, although programs such as LibreOffice are also available in a non-installed format—they're perfect if you want to carry around a toolkit of apps on a USB stick. And you can



Cameyo enables you to run full apps, such as Celestia, within a browser.

CREATE PORTABLE APPS

Installing isn't the be all and end all of software. Check out http://portableapps.com—you'll find a vast range of apps that run comfortably from a USB stick without marking your precious PC even slightly. But what if your favorite app doesn't offer a portable version? Most programs can be made portable using Cameyo (www.cameyo.com), a system that uses the concept of a virtual machine to package up all the components of an application into a single executable file, either on your desktop or, excellently, online. We're not done with installers entirely, however; in order to create a Cameyo package, you need to fire it up, run the installer, and tell it when the installation has finished. It detects the changes made to the filesystem, and swallows them into its own virtual environment. When you then run the app, it finds the files exactly where it expects them to be, not even knowing that it's running in virtual space.

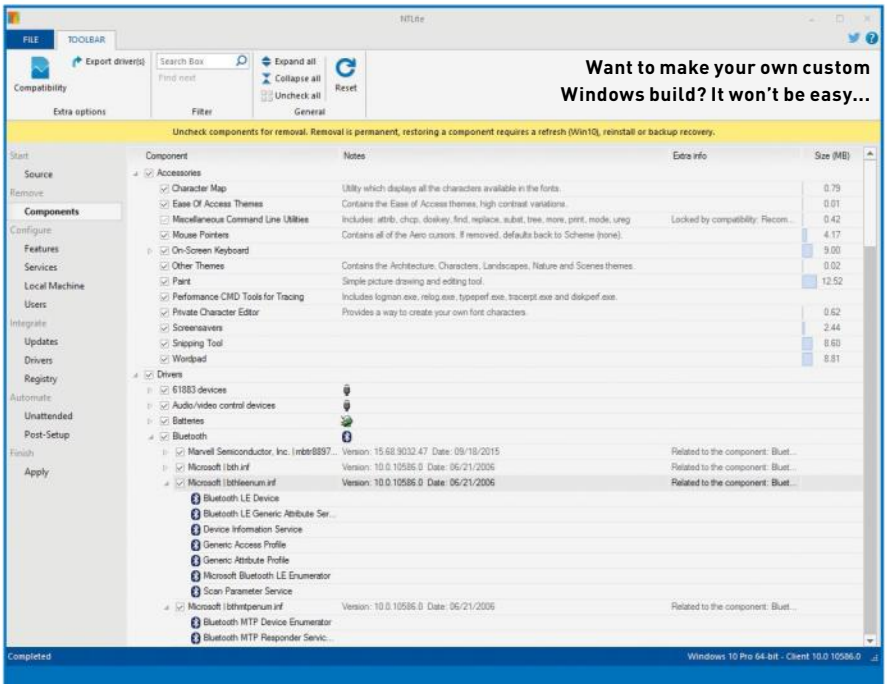
Cameyo's commitment to portability extends beyond USB sticks full of apps, though. You can run your stuff entirely online with its cloud hosting service (session time is limited if you're a free user), or take advantage of its library of portable apps, all of which are ready to go in its online repository. This is especially useful if you're using a managed PC—at work, for example—where you might be denied access to software you need. Register yourself a Cameyo account, head to the site, and (as long as your network administrator isn't wise to it) you gain virtual access to some of the best free apps out there. Nothing to install, no trace left behind. It's like you were never there at all.

Need a quick and easy way of downloading and installing? Try ChocolateyGUI.

even make your own, in a roundabout way; see "Create Portable Apps" (pg. 43).

We have no doubt that you've installed programs before. Taking you through the ins and outs of clicking "Next" a few times in the course of a traditional software installation would be insulting your intelligence. But, as you may have guessed by the extent of this feature, the standard way is not the only way of going about things. The regular way, perhaps, but not the best in all cases.

You may, for example, have grabbed some of the rare decent software from the Windows Store, Microsoft's poorly-policed den of application iniquity. Whatever your feelings on its content, it has a number of advantages—Windows Store apps run in a sandboxed mode, isolated from the main OS, which means that even if something malicious slips through, it can't attack your PC directly, and installing, removing, and updating Store apps is quick and easy. The technically minded might avoid it, and there are other ways of sandboxing apps you might not know of (see "Sandboxing Applications" on pg. 47), but don't underestimate its convenience. So that's one alternative, but let's explore some of the other ways of getting software on your PC.


NTLite
FILE
TOOLBAR
Want to make your own custom Windows build? It won't be easy...
Uncheck components for removal. Removal is permanent, restoring a component requires a refresh (Win10), reinstall or backup recovery.
Component
Notes
Extra info
Size (MB)
Completed
Windows 10 Pro 64-bit - Client 10.0.10586.0

CUSTOM WINDOWS INSTALL

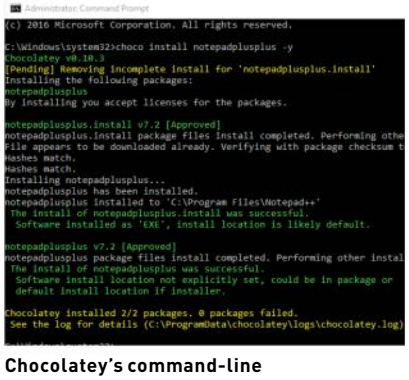
Installing Windows from scratch, particularly if you're doing it repeatedly, is an absolute pain. Although we've talked about ways of installing batches of software at one time in the main feature, that's not your only option. If you're deploying a batch of machines, you could do it using a system image—essentially a fully installed version of Windows, with all the software you're going to need, that you copy wholesale on to a new hard drive. Microsoft provides a tool called the Windows Assessment and Deployment Kit to help with this task, which includes ImageX, an application that can deal with the creation and deployment of system images. Find out more and download the Windows ADK at https://developer.microsoft.com/en-us/windows/hardware/windows-assessment-deployment-kit, and make sure you run Sysprep (included with Windows) before making your image, to strip out everything machine-specific, including Windows license keys.

This is all rather complex and, frankly, quite redundant for most users. You'll probably be more interested in having a customized Windows build on hand for those odd occasions when you need to reinstall your operating system. NTLite (www.ntlite.com) is the perfect choice for this; it's a tool that helps you, yes you, create a custom Windows build, integrating software updates, adding the software of your choice, and even setting it to install completely unattended. You can use it to remove Windows components, too, meaning you end up with a streamlined install, and you can automate post-installation tasks in order to avoid that tedious early-days rigmarole. The free version is absolutely adequate unless you're looking to use it for those IT manager tasks we're trying to avoid, although don't make the mistake of thinking it's a way of avoiding complexity completely. Building an NTLite Windows package is a task that requires a good few hours and a lot of coffee.

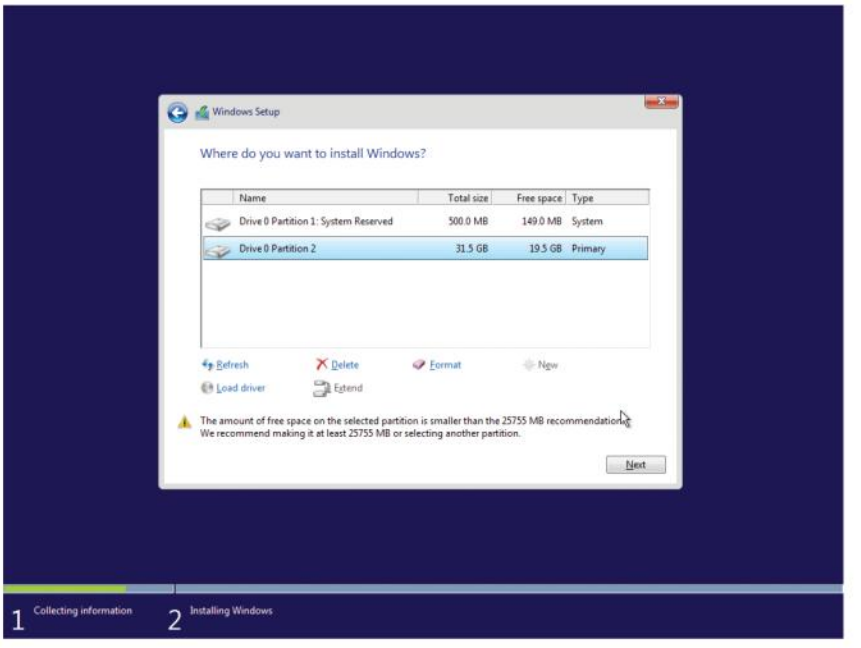
BATCH MANAGEMENT

Sometimes you're starting entirely from scratch with a clean Windows installation that you need to get up to speed in a hurry. Problem is, deploying a new machine can be a massive slog of a job. Collecting together the items you need is one thing, but running through the individual installation processes of all that software is time-consuming and labor-intensive, particularly if you're dealing with programs that include sneaky shovelware in their installers. One wrong click and you're infested, meaning it's not even a job you can do on autopilot. But there's a tried and tested solution that has been dealing with all that nastiness for a number of years, and it's even applicable if you're not installing a machine from scratch.

Ninite (www.ninite.com) compresses all that work into a single job, then deals with all the effort for you. It installs everything you need, preselected to your specifications, as long as it's in the extensive list of supported software, without any hassle. Head over to the site, check a few boxes for your desired apps, and click the big button to download the installer. Run it, and Ninite automatically gets hold of the latest versions of your chosen free programs—which range from security and development tools to messaging and creative apps—and installs them in the background. They all end up


(c) 2016 Microsoft Corporation. All rights reserved.
C:\Windows\system32>choco install notepadplusplus -y
Chocolatey v0.10.3
[Pending] Removing incomplete install for 'notepadplusplus.install'
Installing the following packages:
notepadplusplus
By installing you accept licenses for the packages.
notepadplusplus.install v7.2 [Approved]
notepadplusplus.install package files install completed. Performing othe
File appears to be downloaded already. Verifying with package checksum t
Hashes match.
Hashes match.
Installing notepadplusplus...
notepadplusplus has been installed.
notepadplusplus installed to 'C:\Program Files\Notepad++'
The install of notepadplusplus.install was successful.
Software installed as 'EXE', install location is likely default.
notepadplusplus v7.2 [Approved]
notepadplusplus package files install completed. Performing other instal
The install of notepadplusplus was successful.
Software install location not explicitly set, could be in package or
default install location if installer.
Chocolatey installed 2/2 packages. 0 packages failed.
See the log for details (C:\ProgramData\chocolatey\logs\chocolatey.log)

Chocolatey's command-line goodness tastes great.



Partitioning your hard drive when installing Windows can be a wise move.

in their default locations, and Ninite also ensures that those clandestine crapware boxes are never clicked. While you can't use it for automatic uninstallation unless you opt for the pro version ($20 a month, which also gets you the ability to perform network installs), it does support upgrading; an occasional run is all it takes to keep all of the applications on your system up to date.

PACKAGE MANAGEMENT

Although this feature is dealing with Windows, it would be a canny move to take a look at what the competition is up to. Most flavors of Linux are perfectly capable of installing software from files that have been directly downloaded—however, that's not the usual method. Linux tends to rely on a disparate group of package managers, small tools that can download, install, update, and remove software—thus dealing with both the hassle of finding it and installing anything else your machine might require to get it running.

Windows has been employing its own under-the-hood package manager for some time, a Powershell app called PackageManagement, which is a fork of open-source downloader OneGet. It is bafflingly complex—mastering it is a task for another day, although if you're intrigued enough to experiment, you can read more about it at http://bit.ly/2gstsvW. Better, we think, to start with something more user-friendly and sweet.

Chocolatey is the delicious-sounding Windows analog to Linux tools such as apt-get, yum, and pacman, and it works in much the same way. Microsoft even uses its framework (which spawned from open-source app NuGet, just to add to the complexity of the software management family tree) as part of PackageManagement, which is a ringing endorsement. To get the command-line version installed, open up an administrative command prompt by holding Shift, right-clicking the "Start" button, and selecting "Command Prompt (admin)." Head over to www.chocolatey.org/install, then copy and paste the top install line into your command prompt. Let it run for a while, then close and reopen the window once the C:> prompt reappears.

Whatever your feelings on its content, the Windows Store has advantages

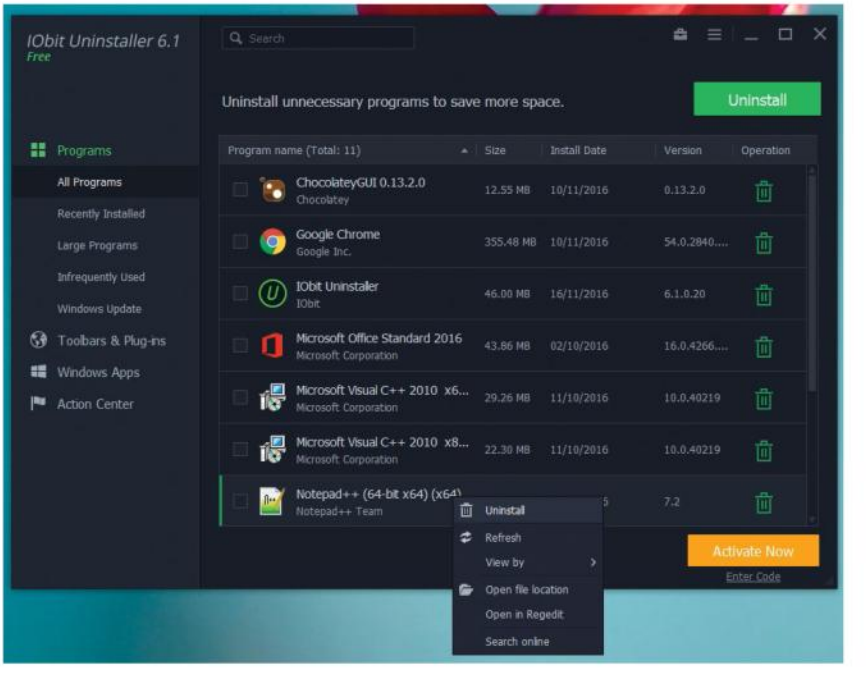
The first thing to try is, we have to admit, a little recursive. Try typing:

```
choco upgrade chocolatey
```

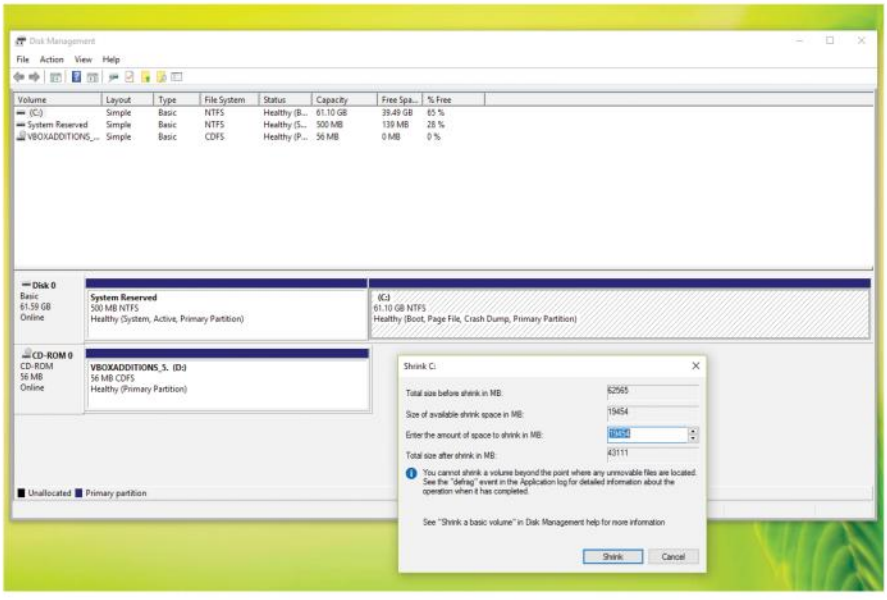
into a fresh command prompt, and you'll see Chocolatey's interface in action as it heads off to see whether there's a new version of itself available. There won't be, of course, because we've just installed it. But if there were, it would download and perform the upgrade autonomously. Let's get hold of something a little more useful now:

```
choco install notepadplusplus -y
```

grabs excellent text editor Notepad++ from the Internet, and safely ensconces it on your system, forgoing any standard Windows installer. The "-y" part on the end of that command means you tacitly accept any confirmations that might come up during the install, so it happens in an automated manner. Replace "install" with "upgrade" or "uninstall" to perform those tasks, and check out the Chocolatey docs at www.chocolatey.org to find out more—there's



Uninstalling is easy—and comprehensive—with IOBit's tool.


Disk Management
File Action View Help
Volume Layout Type File System Status Capacity Free Spa... % Free
(C:) Simple Basic NTFS Healthy (B... 61.10 GB 39.49 GB 65 %
System Reserved Simple Basic NTFS Healthy (S... 500 MB 139 MB 28 %
VBOXADDITIONS_... Simple Basic CDFS Healthy (P... 56 MB 0 MB 0 %
Disk 0
Basic
61.59 GB
Online
System Reserved
500 MB NTFS
Healthy (System, Active, Primary Partition)
(C:)
61.10 GB NTFS
Healthy (Boot, Page File, Crash Dump, Primary Partition)
CD-ROM 0
CD-ROM
56 MB
Online
VBOXADDITIONS_5. (D:)
56 MB CDFS
Healthy (Primary Partition)
Unallocated
Primary partition
Shrink C:
Total size before shrink in MB:
62565
Size of available shrink space in MB:
19454
Enter the amount of space to shrink in MB:
Total size after shrink in MB:
43111
You cannot shrink a volume beyond the point where any unmovable files are located. See the "defrag" event in the Application log for detailed information about the operation when it has completed.
See "Shrink a basic volume" in Disk Management help for more information
Shrink
Cancel

Windows' Disk Management tool can split up any drive.

a huge number of ways to use it via the command line.

You may be more comfortable with a graphical version, however; use Chocolatey to install the package chocolateygui, and, once it's complete, you'll find it in your Start menu as usual. It's an easy interface through which you can manage the packages that you've installed on your system, and clicking the "Chocolatey" tab on the left leads you to the other applications you could have Chocolatey manage for you. The next time you need a piece of software, head to Chocolatey, type the name of the app in its search bar, and we'd wager it'll be there.

SPACE MANAGEMENT

We're spoiled by today's enormous spinning drives and ever-growing SSDs. Space doesn't tend to be an issue. But managing it really should be, both in terms of what's there and where you're putting it. Yes, Windows search can dig things up quite readily, but despite Microsoft's attempts to improve it, searching on NTFS drives is simply not a quick task. However, if your files are well, er, filed, you may never need to do a Windows search again.

Consider, before you do anything rash, changing your default installation directory. By default, most applications you install either nestle in the "Program Files" or "Program Files (x86)" folders, splitting them up between those that run natively in 64-bit (the former) and those that don't. Logically, this makes sense; practically, 64-bit Windows is now the mainstream, 32-bit applications are entirely compatible with 64-bit systems, and there's no reason to split them apart in this way. It's just confusing. But during each program installation (bar those of poorly-coded programs that rely on specific directories to run), you are given a choice as to where you install your software. Setting up your own folder structure—say, a "Programs" folder, with folders within labeled "Music," "Office," et al—is a great way both to neaten up your collection and find out what you have installed when the Start menu begins to get a bit unruly. It's a five-minute manual job that will make life easier in the future.

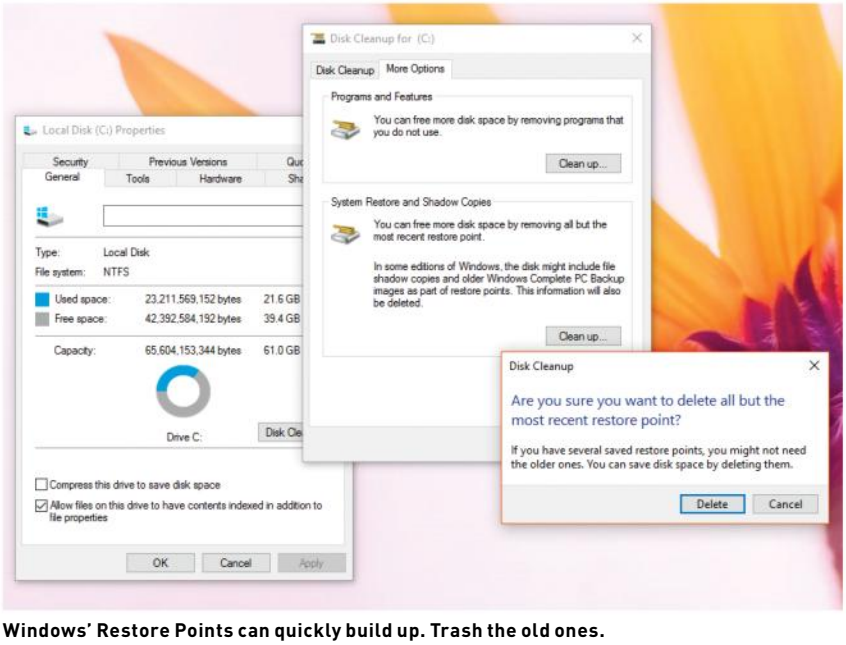
Desktop Windows isn't nice enough to offer folder quotas for files in the same way its server-focused skew does. Quotas, as you might expect, help control the amount that users are allowed to store. Restricting

Drive space doesn't tend to be an issue. But managing it really should be

yourself in this manner is a great way to make sure you're cleaning out the dead wood regularly—if you're forced to make room every time you want to stick a new game or program on your system, those tough decisions suddenly get much easier to make. As we've said, Windows doesn't naturally support such storage handcuffs, but we can get around it with a little cunning and a lot of partitioning.

CHOPPING AND CHANGING

By splitting your drive up into several chunks, you can effectively organize your content and stifle the amount of it that you allow yourself to hang on to. Why not give yourself a virtual D: drive for your programs, an E: drive for photos, a Q: drive for videos, and so on? There are secondary benefits: You can quickly defragment your OS partition without worrying about the rest of your drives; certain malware only affects a single partition, leaving the rest of your data safe; and formatting your Windows partition


Disk Cleanup for (C:)
Disk Cleanup
More Options
Programs and Features
You can free more disk space by removing programs that you do not use.
Clean up...
System Restore and Shadow Copies
You can free more disk space by removing all but the most recent restore point.
In some editions of Windows, the disk might include file shadow copies and older Windows Complete PC Backup images as part of restore points. This information will also be deleted.
Clean up...
Local Disk (C:) Properties
Security
Previous Versions
General
Tools
Hardware
Type: Local Disk
File system: NTFS
Used space: 23,211,569,152 bytes 21.6 GB
Free space: 42,392,584,192 bytes 39.4 GB
Capacity: 65,604,153,344 bytes 61.0 GB
Drive C:
Compress this drive to save disk space
Allow files on this drive to have contents indexed in addition to file properties
OK
Cancel
Apply
Disk Cleanup
Are you sure you want to delete all but the most recent restore point?
If you have several saved restore points, you might not need the older ones. You can save disk space by deleting them.
Delete
Cancel

Windows' Restore Points can quickly build up. Trash the old ones.

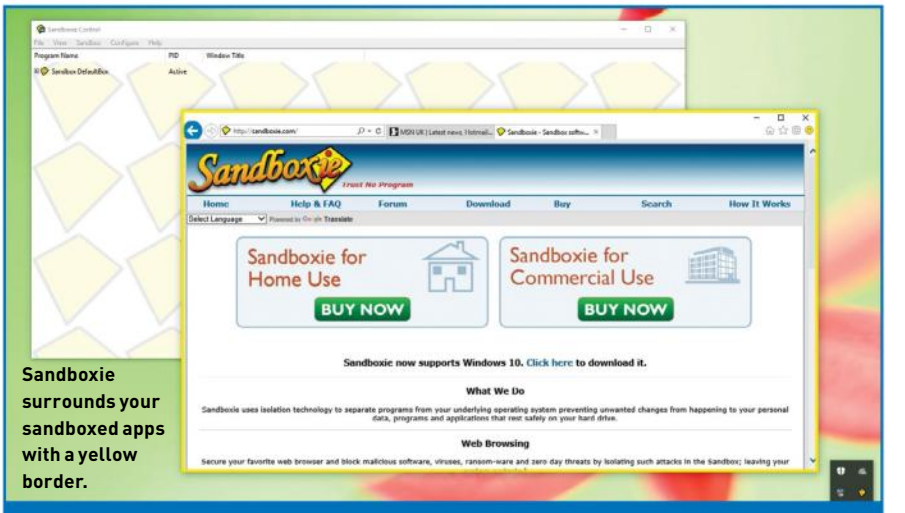
to fully reinstall doesn't mean a loss of your files. That said, as we've expounded upon, your installed programs are unlikely to work properly, thanks to the required references that get scattered through Windows whether you like it or not. Copying files between partitions is also slower on spinning platter drives, due to the physical distance the read/write head needs to travel between the split areas of space.

You might think partitioning is something that can only be done to a clean system. That certainly is the easiest way to make it happen. As you run through the Windows installer, early on (if you don't choose the "Upgrade" option) you're given the option of where to install Windows, at which point you can also chop your disk up, and format it as you see fit. We'd leave at least 32GB for Windows itself—if you're running an SSD and a magnetic drive in parallel, use the SSD for the operating system. Doing it this early is beneficial both in terms of instilling an ethos of organization to your system, and for speed—Windows won't need to shuffle itself around or be defragmented to make space for a new partition.

POST PARTITIONING

It's likely, though, that you're not going into this from scratch. And that's OK; Windows' own Disk Management tool (right-click the "Start" button, and select "Disk Management") is all too happy to slice up the drives of any living system. Open it up, and you may see that what you thought was a simple drive actually consists of several partitions; we tried it on a laptop we had hanging around—one that had seen itself upgraded from Windows 8 to 8.1 to Windows 10 to the Anniversary Update—and found a host of recovery partitions and other empty space. It might be tempting, seeing this, to ditch this wasted space, but without knowing exactly what's on each partition, we advise that you tread very carefully.

Find your main partition, or a partition you want to split, in the graphical representation. Right-click it, and select "Shrink partition" to begin the operation of creating some empty space. It's here that you'll see just how much you're allowed to shift; so-called "unmoveable" files put a damper on this in a hurry, but this problem can often be sorted by (temporarily) disabling System Restore or running Disk Cleanup. You can shrink your main partition down to the individual megabyte, but be sure to leave a reasonable amount of space free on your Windows partition in order that it can accommodate system updates and

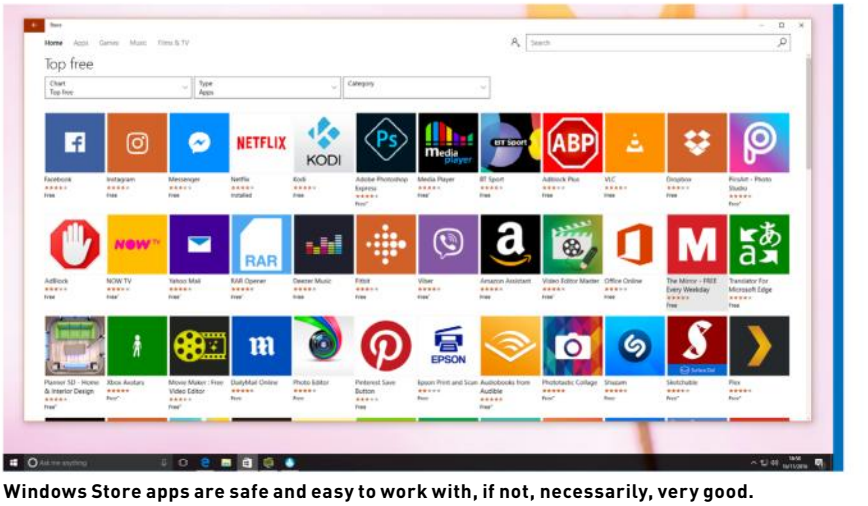


Sandboxie surrounds your sandboxed apps with a yellow border.

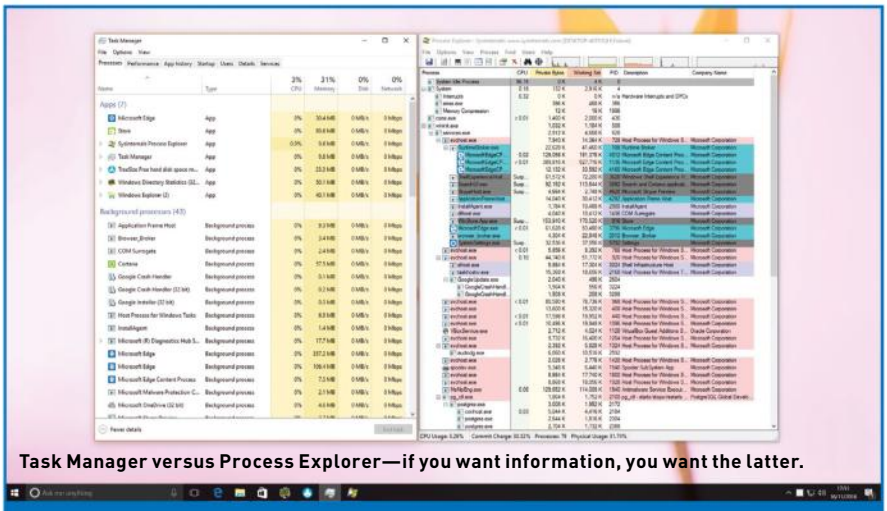
SANDBOXING APPLICATIONS

The Windows Store is clever. It shuts its apps away in their own little capsules, protecting your computer from rogues, and from the influence of anything untoward that may be swimming around your OS. Most standard Windows apps, though, don't have this facility. Unless, that is, you add it yourself. Sandboxie (www.sandboxie.com) does exactly this. If you've grabbed something a bit sketchy and need to test it out without risk, you can install it within a sandbox to ensure it doesn't get its tentacles in. Running a web browser on a family PC? Run it via Sandboxie to prevent your kids from downloading awful PC gremlins, or to stop your mom from inadvertently "upgrading" something she shouldn't. Nefarious threats such as CryptoLocker are completely negated by running a sandboxed browser, unless your mother somehow works out how to store her important documents within the sandboxed folder structure—that's behavior you need to curb on your own, though. Once you've set it up, you can open your sandboxes (through the app) as standard folders using Explorer.

Sandboxie can be used for free, though you get a nag screen after 30 days, and miss out on a few features only available to subscribers—if it's something you use regularly, you can sign up for $20.95 per year. There's a secondary benefit to all this, too: Sandboxie tucks all of the data from a program away in a single contiguous chunk of hard drive space, meaning deleting a sandboxed app doesn't leave the same fragmented storage you might get after uninstalling a regular program. It's a very minor thing, and there's every chance you're not even slightly worried by the behind-the-scenes goings-on of your data, but a well-organized drive is a fast drive.



Windows Store apps are safe and easy to work with, if not, necessarily, very good.



Task Manager versus Process Explorer—if you want information, you want the latter.

FINDING RESOURCE HOGS

Although we've mainly had our eyes set firmly on your hard drive in this feature, your applications don't just take up space there. Certain programs can have a disastrous negative effect on the overall running of your system, and might even be running on your system without your knowledge. Task Manager can do a pretty good job of showing you what's going on; hit Ctrl-Shift-Esc to open it, then "More Details" to see a categorized list. Right-click the column headers, select "Type," then click it to sort the apps in the list, and have a look through to see what's running. Keep an eye out for things that hog your CPU, memory, and disk access, and look at the "Performance" tab for a graph of the usage of these elements over time. The "Details" tab can offer a bit more insight into exactly what everything in the "Processes" tab is actually supposed to do. Do a full reboot of your system, reopen Task Manager, and have a good look at what's running for anything you wouldn't expect to be there had you not opened it yourself. In all likelihood, it's there because of some autorunning application, so head to the "Start-up" tab, and disable any items you don't feel you need. This can often make programs load a little slower—they have to load these components at run time, instead of them being ready when you boot your PC, but they can always be enabled again at a later time if you notice a problem.

Spying on running software can get rather addictive, and it's fully possible to delve even deeper than the Task Manager allows. Try Process Explorer (https://technet.microsoft.com/en-us/sysinternals/processexplorer.aspx), one of the Microsoft Sysinternals tools, to see what's happening on your system in ridiculous detail.

Some apps just won't be uninstalled without some brute force.

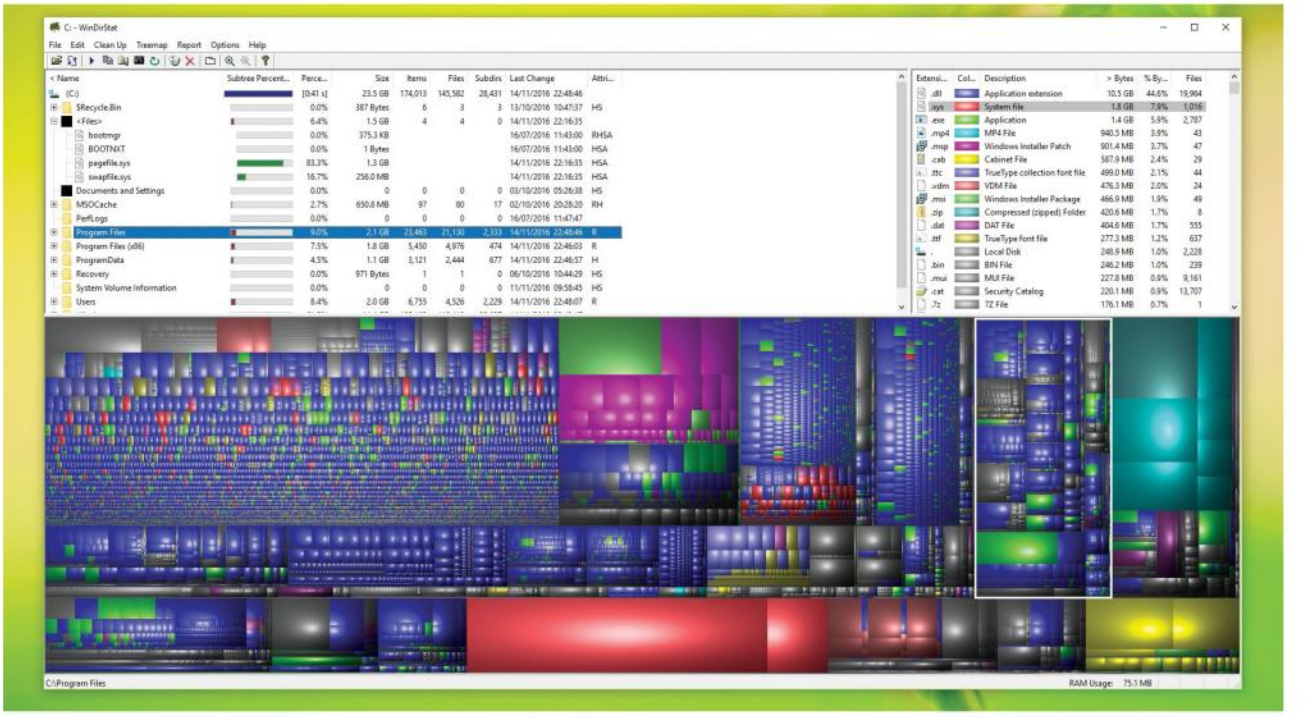
virtual memory. Once the shrink operation is complete, create your new partition or partitions by right-clicking the now unallocated empty space, selecting "New simple volume," and allocating your desired amount of space, repeating the process for each new partition you wish to create.

CLEANING UP

Where, oh where does the space go? An established system tends to eat up hard drive bytes somewhat mysteriously, and if you're obsessive about watching your drive stats, you may be wondering what's going on. We can't tell you precisely, although there are a few obvious culprits to look for if you're getting too low for that big app install. First, and most prevalent, is System Restore points. These have the potential to be huge on their own, but if you're doing frequent installs, your Windows system may be making loads of them, and keeping a needless archive. Disk Cleanup helps you delete all but the most recent. To find the option, open up an Explorer window, right-click your OS partition (or just your C: drive), select "Properties → Disk Cleanup → Clean Up System Files," then head to the "More Options" tab. Disk Cleanup can also clean up temporary files and the like, although you may not save a vast amount of space this way.

So where are the hogs? The best way to find out is to use a visual method, rather than poking through Windows Explorer poring over file sizes. For this you have two primary choices: TreeSize Free (www.jam-software.com/treesize_free) and WinDirStat (http://windirstat.net). TreeSize feels very much like a natural extension of Windows Explorer. Install it, and it runs from a context menu; right-click a folder or drive, fire it up, and it very quickly trawls through, and finds out exactly what's inside, offering you the option of reopening as an administrator if any of your files are locked down. It then lists your folders by their size, with a handy bar graph indicator in the background. Drill down into the largest folders, and you'll find your files—you can right-click them for a standard Explorer context menu, but be careful not to delete anything you don't explicitly know the meaning of.

WinDirStat is a similar tool, but infinitely cooler in that it ramps up the visual finery to a huge extent. Give it a run, select your drive (or "All local drives" if you want to be unnecessarily thorough), then wait as it laboriously traverses your disk in search of meaty files—it's certainly nowhere



WinDirStat's rectangular map is incredibly useful for finding gargantuan files.

near as fast as TreeSize. When it's done, though, you'll see the benefit: a color-coded map of your entire drive, with rectangles representing the size of files, collected into larger rectangles that represent folders. Click a big file and check the status bar to see exactly what it is, and right-click to find a context menu that will help you open the folder in Explorer or copy its path to your clipboard. Click a folder or file in the top left pane, and it highlights it in the visual view, or use the top-right pane to hunt down files of particular types. They're listed, by default, in order of the size those files take up, so it's a good way to discover the space-munching culprits.

TIME TO UNINSTALL

Once you've found the monsters—or when you're simply done with your apps—how do you remove them? You might be surprised, but we're going to suggest that the best way to clean up an old app is by using Windows' own built-in interface, which you can find in the "Programs and Features" section of the Control Panel. Removing files using this tool automatically fires up their included uninstaller (or, in the case of MSI-installed components, the Windows built-in equivalent), which should mean all trace of the app is wiped away. Make sure, if using this method, that you remember to check any boxes that also remove settings files or equivalent because, while they're not going to take up much space, any redundant files you leave on your drive slow down indexing and basically irritate you no end.

If you're a fan of overkill and salting the Windows earth, try a tool such as IOBit Uninstaller (www.iobit.com). It's available as a portable app from http://portableapps.com (because if anything should be, it's a tool that helps you get rid of installed software), and it's a great way of making sure every trace of an app is removed. Set it to work, and it bangs through your registry and filesystem to find files traditional uninstallers might have missed. If a program doesn't appear to be installed—as in, it doesn't appear in "Programs and Features"—you can also point IOBit Uninstaller at its executable file, and it does its best to do an automatic uninstall. It's not flawless, but it's pretty damn good.

SUPER REMOVAL

Uninstalling apps you've deliberately added to your PC is one thing. Hacking away the dead wood that Microsoft includes by default in Windows is another. It doesn't look easy—there's not even an obvious way to remove those horrible, redundant entries from the Windows 10 Start menu. At least, there doesn't seem to be, but there's a sneaky feature built in to Win 10: Right-click an unwanted app in the Start menu list and, if it can be easily gotten rid of, an "Uninstall" option is present in the context menu. But what of the ream of apps that can't be chopped out in this way?

For this you need Powershell, the super-command line that's bundled with Windows. Find it in the application list, right-click it, select "Run as administrator," then type the following to remove (in this example) 3D Builder:

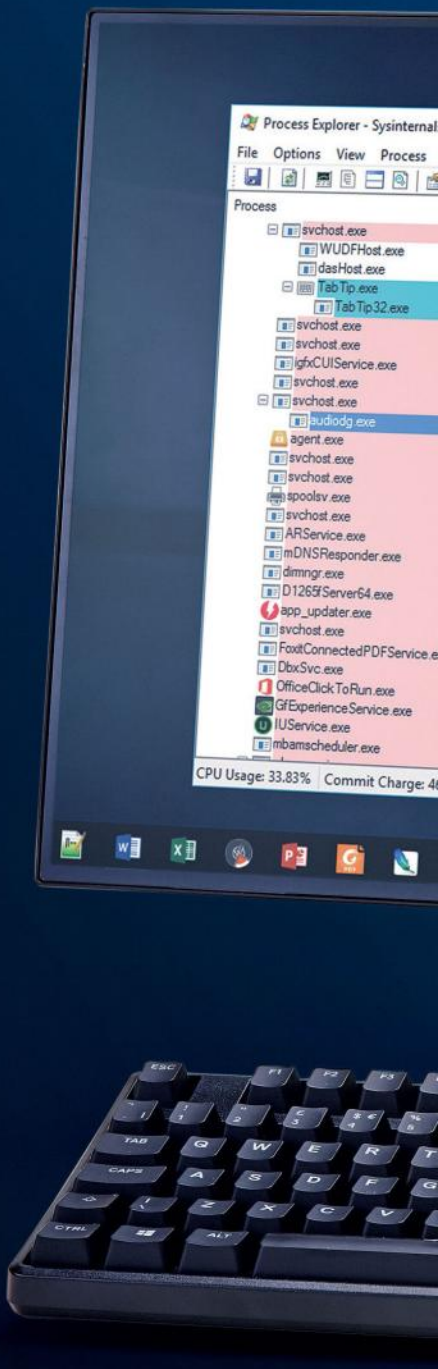
```
Get-AppxPackage *3dbuilder* | Remove-AppxPackage
```

This uses Get-AppxPackage to seek out the appropriate program, then pipes its location and information to the Remove-AppxPackage tool; the phrase within the asterisks can be replaced with the specific package names for a host of applications, though these aren't immediately obvious, so here's the basic list:

3D Builder: *3dbuilder*
Alarms and Clock: *windowsalarms*
Calendar and Mail: *windowscommunicationsapps*
Camera: *windowscamera*
Groove Music: *zunemusic*
Maps: *windowsmaps*
Movies & TV: *zunevideo*
OneNote: *onenote*
People: *people*
Photos: *photos*
Store: *windowsstore*
Voice Recorder: *soundrecorder*
Xbox: *xboxapp*

FORENSICALLY EXAMINE YOUR PC'S PROCESSES

Take a peek at the inner workings of Windows with Task Manager. By *Nick Peers*

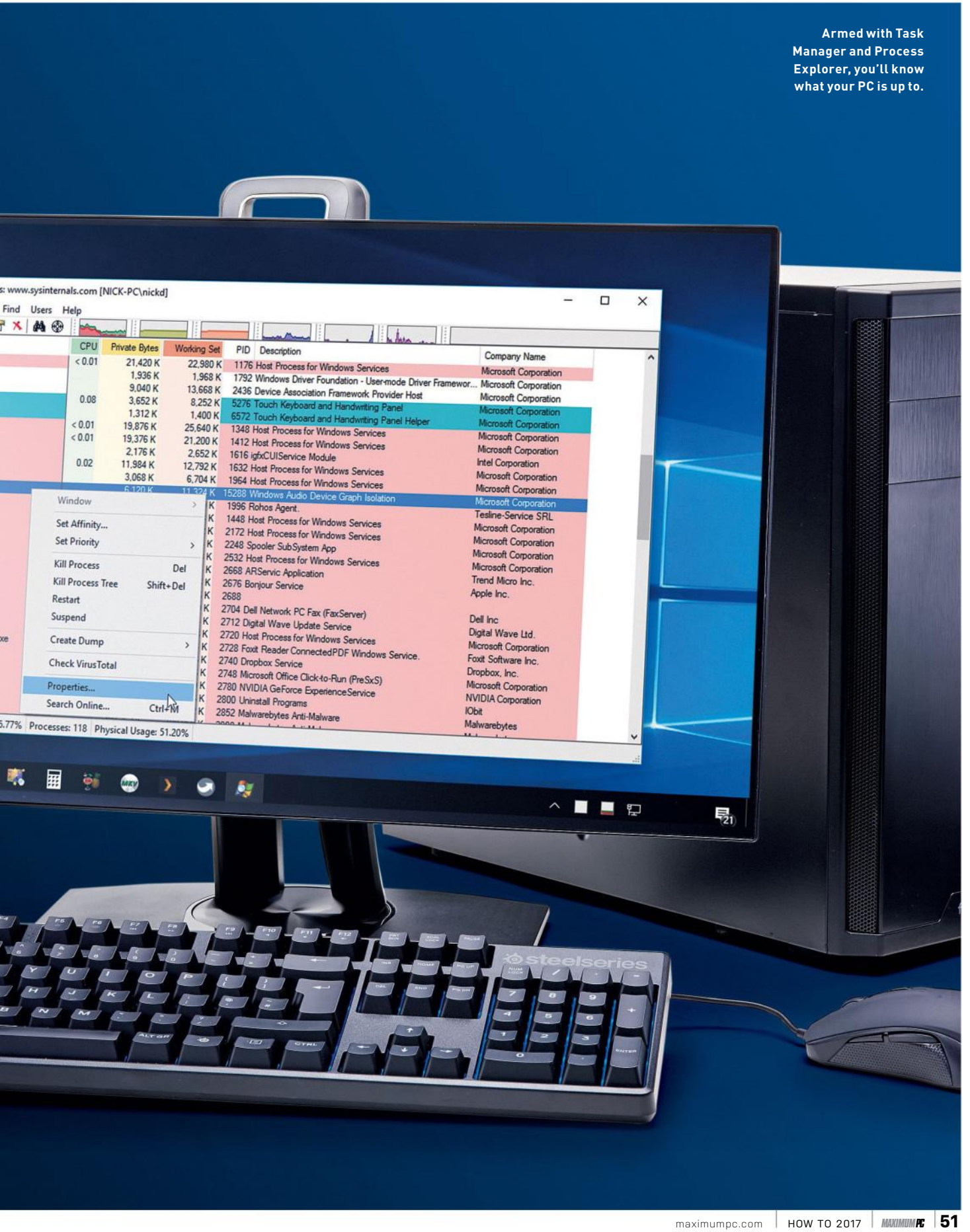


Ever wondered what goes on under the hood of Windows? If your PC is running smoothly, doing its job, then probably not. It's when things start to go wrong—your PC slows to a crawl, or non-responsive application errors keep popping up—that you suddenly take a keen interest. There are plenty of tools out there that promise to speed up your computer, fix errors, and make things as good as new again (whatever that means), but there's always an element of risk involved in trusting your PC to a program that doesn't really explain what it's doing, failing to point out that cleaning out the Registry doesn't—on its own, at any rate—speed things up, and, more often than not, introduces problems you later can't unpick to resolve without a refresh or, worse still, full-blown reinstall.

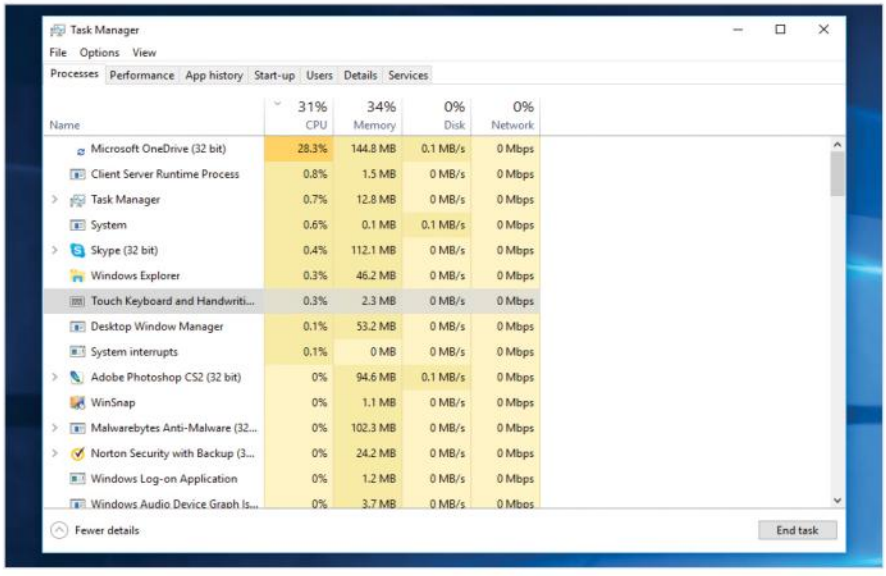
We may live in a post-truth world, but your PC doesn't care about any of that. Knowledge is power, and understanding how Windows works arms you with the insights you need to make more informed choices about what to do the next time your PC decides to slow to a crawl. In this feature, we're going to take a close look at the programs, processes, handles, and threads that make up the bulk of what your PC does. And if all that sounds like gobbledegook, don't worry, because we'll also explain how everything fits together to help you understand exactly what's going on.

We kick things off by having a look at Windows 10's powerful Task Manager tool to take a closer peek—you'll even learn a clever trick that can sometimes help bring frozen applications back to life. And if you want to go deeper, we'll take you on a tour of Process Explorer, which offers a forensic look at exactly what's going on—both in the foreground and behind the scenes. You'll discover how to free up system resources, track down troublesome processes, and generally keep your PC running a bit more smoothly.

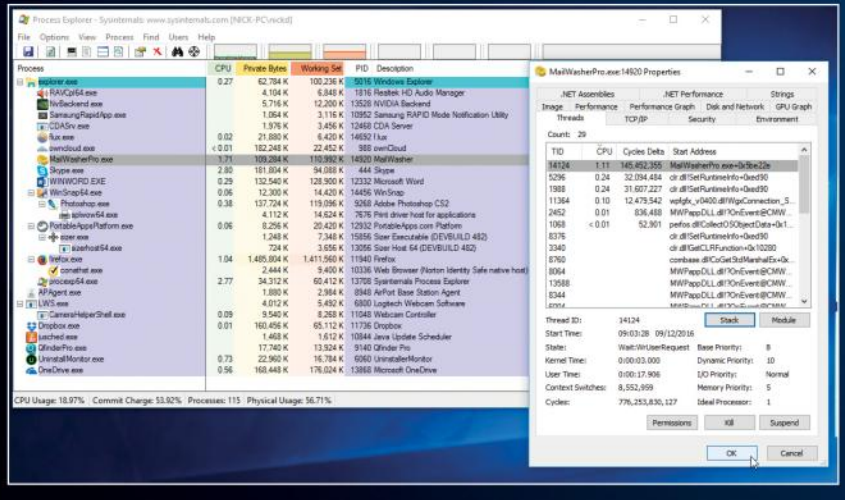
We'll also take a brief look at some other tools that can help you monitor your PC and track down fixes to your problems. But enough natter—it's time to arm yourself with the tools and techniques you need to better understand your PC.


s: www.sysinternals.com [NICK-PC\nickd]
Find Users Help
CPU Private Bytes Working Set PID Description Company Name
< 0.01 21,420 K 22,980 K 1176 Host Process for Windows Services Microsoft Corporation
1,936 K 1,968 K 1792 Windows Driver Foundation - User-mode Driver Framewor... Microsoft Corporation
9,040 K 13,668 K 2436 Device Association Framework Provider Host Microsoft Corporation
0.08 3,652 K 8,252 K 5276 Touch Keyboard and Handwriting Panel Microsoft Corporation
1,312 K 1,400 K 6572 Touch Keyboard and Handwriting Panel Helper Microsoft Corporation
< 0.01 19,876 K 25,640 K 1348 Host Process for Windows Services Microsoft Corporation
< 0.01 19,376 K 21,200 K 1412 Host Process for Windows Services Microsoft Corporation
2,176 K 2,652 K 1616 igfxCUIService Module Intel Corporation
0.02 11,984 K 12,792 K 1632 Host Process for Windows Services Microsoft Corporation
3,068 K 6,704 K 1964 Host Process for Windows Services Microsoft Corporation
15288 Windows Audio Device Graph Isolation Microsoft Corporation
1996 Rohos Agent. Tesline-Service SRL
1448 Host Process for Windows Services Microsoft Corporation
2172 Host Process for Windows Services Microsoft Corporation
2248 Spooler SubSystem App Microsoft Corporation
2532 Host Process for Windows Services Microsoft Corporation
2668 ARServic Application Trend Micro Inc.
2676 Bonjour Service Apple Inc.
2688
2704 Dell Network PC Fax (FaxServer) Dell Inc
2712 Digital Wave Update Service Digital Wave Ltd.
2720 Host Process for Windows Services Microsoft Corporation
2728 Foxit Reader ConnectedPDF Windows Service. Foxit Software Inc.
2740 Dropbox Service Dropbox, Inc.
2748 Microsoft Office Click-to-Run (PreSxS) Microsoft Corporation
2780 NVIDIA GeForce ExperienceService NVIDIA Corporation
2800 Uninstall Programs IObit
2852 Malwarebytes Anti-Malware Malwarebytes
Window
Set Affinity...
Set Priority
Kill Process Del
Kill Process Tree Shift+Del
Restart
Suspend
Create Dump
Check VirusTotal
Properties...
Search Online... Ctrl+M
Processes: 118 Physical Usage: 51.20%
steelseries

Armed with Task Manager and Process Explorer, you'll know what your PC is up to.


Task Manager
File Options View
Processes Performance App history Start-up Users Details Services
Name
31% CPU
34% Memory
0% Disk
0% Network
Microsoft OneDrive (32 bit) 28.3% 144.8 MB 0.1 MB/s 0 Mbps
Client Server Runtime Process 0.8% 1.5 MB 0 MB/s 0 Mbps
Task Manager 0.7% 12.8 MB 0 MB/s 0 Mbps
System 0.6% 0.1 MB 0.1 MB/s 0 Mbps
Skype (32 bit) 0.4% 112.1 MB 0 MB/s 0 Mbps
Windows Explorer 0.3% 46.2 MB 0 MB/s 0 Mbps
Touch Keyboard and Handwriti... 0.3% 2.3 MB 0 MB/s 0 Mbps
Desktop Window Manager 0.1% 53.2 MB 0 MB/s 0 Mbps
System interrupts 0.1% 0 MB 0 MB/s 0 Mbps
Adobe Photoshop CS2 (32 bit) 0% 94.6 MB 0.1 MB/s 0 Mbps
WinSnap 0% 1.1 MB 0 MB/s 0 Mbps
Malwarebytes Anti-Malware (32... 0% 102.3 MB 0 MB/s 0 Mbps
Norton Security with Backup (3... 0% 24.2 MB 0 MB/s 0 Mbps
Windows Log-on Application 0% 1.2 MB 0 MB/s 0 Mbps
Windows Audio Device Graph Is... 0% 3.7 MB 0 MB/s 0 Mbps
Fewer details
End task

Windows 10's Task Manager provides a decent system overview.



Understand Process Terminology

Programs, processes, handles, and threads—what are they, and how do they link together? It can get confusing, particularly given the way that both Task Manager and System Explorer present running programs, processes, and threads.

Programs are a series of files that are combined to provide you with the tools and functionality you use on a daily basis, from a web browser or office package to your game collection. They can also include underlying Windows programs (such as File Explorer) and lower level Services, which work in the background to provide features such as networking and automatic updates.

Processes provide resources to run a program, which are stored in "virtual address space," a reserved portion of RAM. They comprise the program, open "handles" to system objects, which determine what resources are required (such as DLL files), as well as environment variables. Processes are assigned a security context, which determines their level of access to the system, plus a unique process identifier (PID). They're also assigned a priority class, which determines how fast the process runs in relation to other processes. Minimum and maximum "working set sizes" are also applied, to set limits on how much physical memory the process requires.

Each process is split into threads, which allows Windows to allocate CPU time between processes. Each thread can execute any part of the process's code, and shares the process's virtual address space and resources. They have their own properties, such as unique identifiers and exception handlers, and they stop and start to a schedule, so they don't all run at once.

The main focus of our feature is the programs and processes that are running whenever you're using Windows. These include apps, games, and other programs you launch yourself, as well as background processes, such as Windows Services, your security software's auto-protect features, and Windows Explorer itself. Windows ships with its own built-in tool for monitoring and—to some degree—managing all of these in the form of Task Manager.

Task Manager has evolved into quite a powerful tool in recent versions of Windows—launch it by right-clicking the Taskbar. The default basic view merely shows running programs—right-click to close it or switch to that program (handy if it's hidden from view). Note that the "Always on top" option merely ensures that the Task Manager window can't be hidden by other windows.

To tap into Task Manager's full range of features, click "More details," which splits things into a multi-tabbed view. The main tab is "Processes," an expanded view of all the processes and threads running on your PC. By default, these are split into three groups: apps are programs you launch from Windows Explorer; background processes are third-party programs running in the background, and Windows processes refer to core processes related to Windows.

You'll see four additional columns of information, labeled "CPU," "Memory," "Disk," and "Network." These represent the process's usage (as a percentage in CPU terms). You can quickly see which processes are hogging system resources by clicking any of the columns to sort the list accordingly. Once identified, you can decide whether or not to close the program or process in question—if you don't recognize its name, right-click it, and choose "Properties → Details" for a more verbose description, or choose "Search online" to search Bing for both the process name and its underlying filename.

Tip: Cloud storage apps often hog all available network resources, which in turn can result in sluggish performance. Once verified as the culprit in Task Manager, open their settings, and look for a section where you can apply limits to their upload and download speeds—OneDrive users should go to "Settings → Network tab," for example.

Recover Frozen Apps

If a program is not responding, the process should be highlighted—from here, you can attempt to close it by selecting the process and clicking the "End task" button. If that's too drastic a step, you may be able to recover it by right-clicking and choosing "Go

to details." This takes you to the "Details" tab, where processes are listed with more information—their status (running or suspended), the user who launched them (typically you, SYSTEM, or a SERVICE), and a PID (Process ID).

To try to free up a non-responding thread from here, right-click it again, and choose "Analyze wait chain." This lists any threads that are using or waiting to use resources being used elsewhere. Ending the thread may be enough to free up the original process—we've done this a few times in Firefox when an individual tab has become non-responsive, for example.

There are some other handy options under the "Details" tab—you can alter thread priorities here, which in turn can stop particular processes from taking over your PC, and slowing everything else down. Simply right-click the offending process, and choose "Set Priority → Below Normal" to see whether it helps. You can also give threads more priority if you feel they need extra attention, but avoid giving any thread "Realtime" priority, because it brings Windows grinding to a halt.

Another option is "Set affinity." This determines which processor cores a program or service can use—if you have a dual-core CPU or better, you might find older applications designed in the era of single-core processing run better if you limit their access to a specific core, rather than allowing them to use all available cores. In most cases, you'll find Windows is perfectly capable of assigning resources efficiently, so it's of largely academic interest only.

Trim Startup

One other Task Manager tab is worthy of attention: "Start-up." This doesn't just list which programs are set to start with Windows—it provides a "Start-up impact" tab that rates apps' resource usage as "High," "Medium," or "Low." Keep an eye on those rated "High"—if start-up times and overall performance suffer, preventing these from starting with Windows (right-click the program and choose "Disable") may help improve matters.

Task Manager's other tabs enable you to monitor performance over time via a series of graphs ("Performance"), plus keep an eye on apps you've installed through the Microsoft Store by measuring their resource usage over time ("App history"). The "Users" tab is handy when two or more users are logged on at once, providing a list of user-generated running processes. Finally, "Services" provides a cut-down version of which low-level processes are running (or not). You can manually start, stop, and restart services from here, but for more granular control (such as setting a Service's start-up setting), right-click the service, and choose "Open Services."

Process Explorer

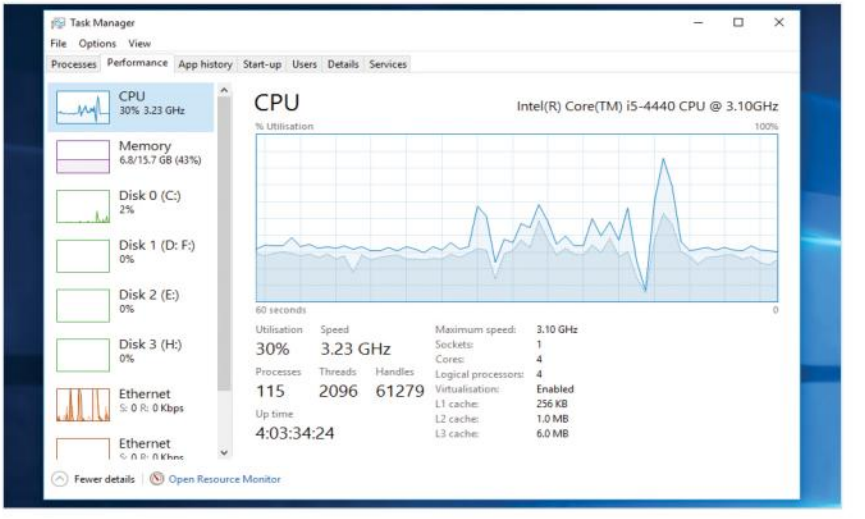
The Windows 10 Task Manager tool goes a long way to giving you a peek inside your system, as well as the tools for dealing with runaway and non-responding programs, processes, and threads. But you can delve even deeper into your system with the help of Process Explorer, a free tool developed by Microsoft's Sysinternals team. Find out more and download it from https://technet.microsoft.com/en-us/sysinternals/processexplorer.aspx—it's completely portable, and can be run directly from your web browser (go to https://live.sysinternals.com/procexp.exe to do so).

We'll assume you're downloading it: once done, right-click "ProcessExplorer.zip," choose "Properties," check "Unblock," and click "OK." Now extract its contents, then right-click either "procexp.exe" or "procexp64.exe" (depending on your Windows system type), and choose "Run as administrator." Process Explorer doesn't require elevated access, but if you want a complete look at your system, you should do so to allow it to peer wherever it needs to.

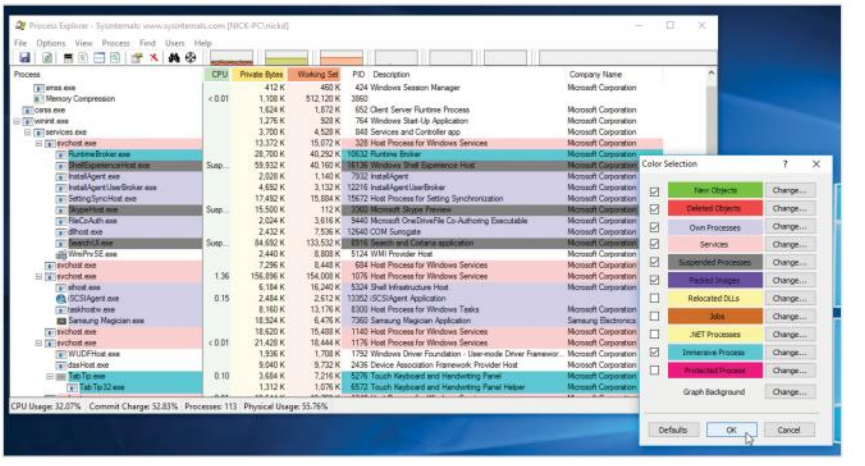
Process Explorer opens to a single-pane window. Expand the "Options" menu, and check "Hide When Minimized" and "Allow Only One Instance." The former option ensures that when you close or hide Process Explorer, it minimizes to the Taskbar Notification area, where a real-time graph lets you keep an eye on CPU usage (roll your mouse over it, and a pop-up window reveals overall CPU usage, as well as that of the most demanding app running). Go to "Options → Tray Icons" to measure additional metrics via their own system tray icons, with seven choices on offer, including "GPU memory" and "Commit" (total predicted memory the system may need at any one time based on current usage).

Dig Deeper

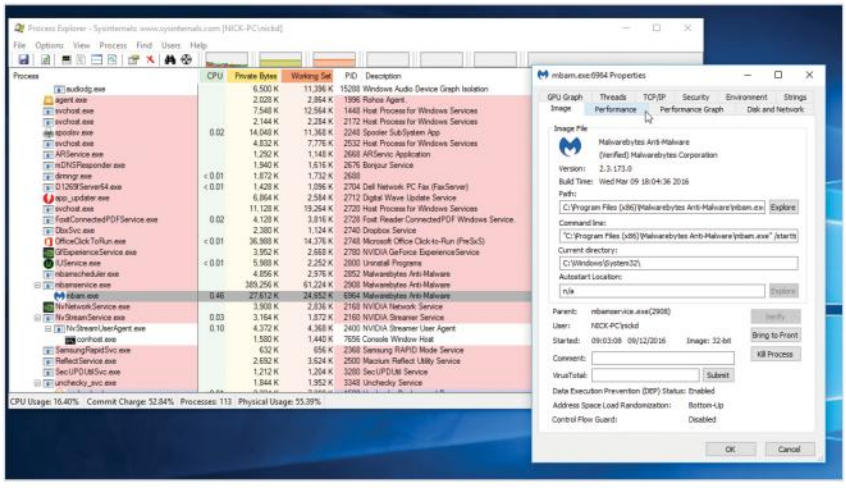
But we digress. Return to the main Process Explorer window, which lists all running



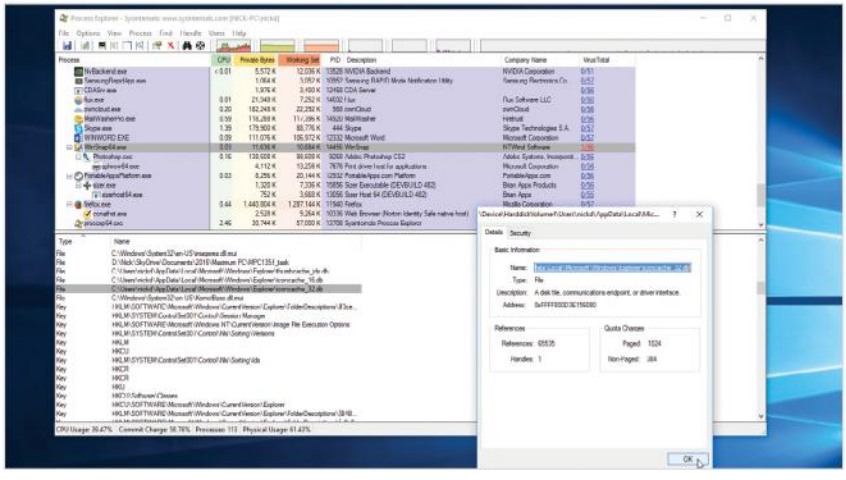
Monitor the ups and downs of your system performance with Task Manager.



All that color isn't just for decoration—find out what it means.



Get the full low-down on any process via its Properties dialog.



Discover what resources your processes are using via handles.

processes. You'll see some processes are nested inside others in a tree-like structure. This makes it clear from which process a particular process or program spawned (for example, if you open a program in the usual way, it appears nested underneath explorer.exe; however, if you open your web browser by clicking a link in another program—Word, say—it appears underneath the parent program instead).

Processes are also color-coded to help you identify what's going on with each—to see what the colors represent, from recently launched threads (green) to threads ending (red), choose "Options → Configure Colors."

Note this view is lost if you click any of the other column headings—such as "CPU"—to determine resource hogs. But if you double-click the process to open its Properties dialog, you can see the name of its parent process underneath the "Image" tab with other useful information (such as which user the process is running under).

As an aside, look carefully at the System process. You'll see an entry marked "Interrupts." This is an artificial process in that it actually tracks the system's interaction with your hardware. If you spot high CPU consumption for this figure, then it indicates a potential problem with your hardware or—more likely—a driver bug. Don't bother clicking it for further information, though—there's nothing to see, literally.

Microscopic Examination

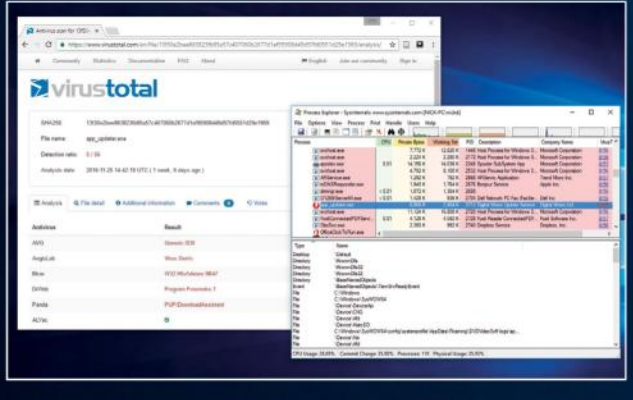
One of the many ways in which Process Explorer enables you to see what's really

Check for Malware

Process Explorer can also help track down potential security risks that are running, by comparing a process's parent file with the VirusTotal online database, which checks files against dozens of reputable antivirus engines. Switch the feature on by choosing "Options → VirusTotal.com → Check VirusTotal.com." Click "Yes" to agree to the VirusTotal terms of service (these are displayed in your browser), and then Process Explorer will submit the hashes of every running process and thread to the VirusTotal website. It also adds a new VirusTotal column to the main view. You'll see a list of clickable links reading "0/56" or "3/57." Each one links to the antivirus scan results for that individual file.

Any files listed as "0/57" or similar have been rated safe by all the antivirus engines used; focus your efforts on those marked in red, where the score is 1 or higher. Click the link and you're taken to a web page of results, with the suspected infections placed prominently at the top, along with the source antivirus engine and suspected infection. Google the result, together with the filename, to see what's out there, but unless there are multiple matches, it's likely to be a false positive.

If your file isn't listed there, that means it hasn't yet been scanned by VirusTotal's engines—right-click the file and



The more flags on VirusTotal, the more dangerous the file.

choose "Submit to VirusTotal" to upload it, then wait for it to be scanned. The results appear in due course.

You can also check files for their digital signatures—double-click the process and switch to the "Image" tab, then click the "Verify" button. Look for "(Verified)," followed by the name of the digital certificate authority under "Image File." This, on its own, is no guarantee of whether or not a file is safe, but it is an extra layer of security.

happening under the hood is through its support for showing detailed information about a process's threads. Switch to the "Thread tab"—ignoring the warning about missing symbol files (not needed unless you've got the chops to go the extra mile, or you're a developer)—and you'll see a list of all threads associated with that process. You get to see the CPU usage for individual threads, as well as the files calling that thread, which helps pinpoint where a resource leak may be occurring. You can kill or suspend individual threads from this dialog box, but save any work before doing so—you could easily bring down the parent process from here, or even Windows itself if you don't know what you're doing.

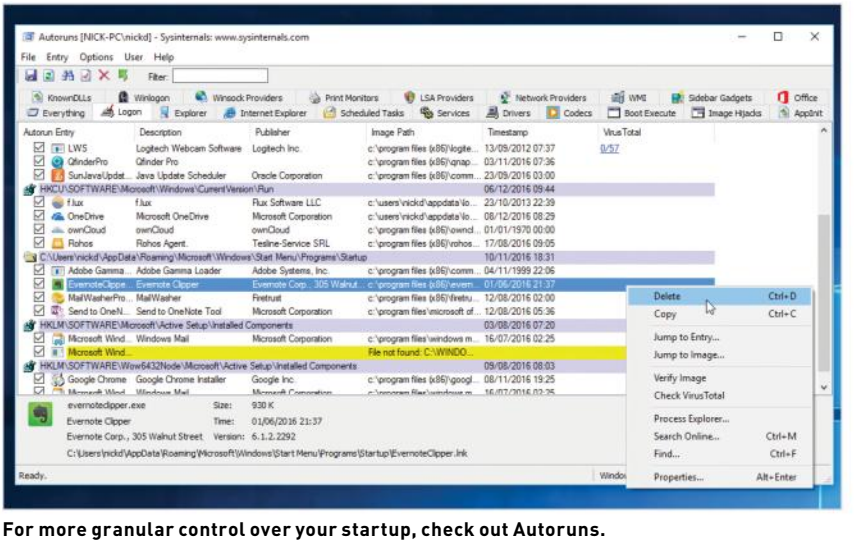
A process's "Properties" dialog contains a wealth of potentially helpful information. Use the "Performance" and "Performance Graph" tabs to measure its impact over time, for example. Switch to the "Service" tab to list which services it utilizes, or select "Environment" to view any environmental variables used by the program. The "Strings" tab is linked to the list of values provided by any DLL files used—these can help identify a process if you're struggling to work out what it relates to.

Handles and DLL Files

Process Explorer also enables you to take a close look at a process's handles and DLL files (the resource files that can be shared between multiple programs). Select your thread and press Ctrl-H—a new pane appears listing its handles. From here, double-click a handle to get more information about it (most specifically, a description of the handle type, such as "Section" or "WindowStation.") It's possible to close individual handles by right-clicking and choosing the "Close" option—but, as with threads, if you don't know what you're doing, it's likely you'll bring the whole process crashing down.

Press Ctrl-D, and this lower pane switches to DLL view, listing all the DLL files that the process in question is accessing. Double-click a DLL file to access its properties—switch to the "Strings" tab and you're shown a list of string values it contains. Press Ctrl-H to switch back to Handles view, or Ctrl-L to toggle the lower pane on and off.

What does this information tell you? It gives you detailed insights into what makes up a process—how it's composed of multiple threads, and what resources it utilizes in the form of handles and DLL files. Not only does it enable you to see exactly what's happening with individual processes, but it also helps you to learn exactly how programs and processes run.


Autoruns [NICK-PC\nickd] - Sysinternals: www.sysinternals.com
File Entry Options User Help
Filter:
KnownDLLs Winlogon Winsock Providers Print Monitors LSA Providers Network Providers WMI Sidebar Gadgets Office
Everything Logon Explorer Internet Explorer Scheduled Tasks Services Drivers Codecs Boot Execute Image Hijacks AppInit
Autorun Entry Description Publisher Image Path Timestamp VirusTotal
Delete Ctrl+D
Copy Ctrl+C
Jump to Entry...
Jump to Image...
Verify Image
Check VirusTotal
Process Explorer...
Search Online... Ctrl+M
Find... Ctrl+F
Properties... Alt+Enter
Ready.

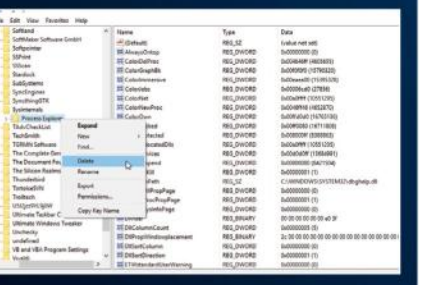
For more granular control over your startup, check out Autoruns.

Get More Help

Process Explorer is a powerful tool, and it can take a while to get your head around it. The Help file is a good place to start—press F1 to access it—but you'll find some handy online resources, too. There's a PDF handout from Kansas State University (http://bit.ly/procexplhandout) that provides a good introduction—it was written back in 2009, but is still relevant. And don't forget the official Process Explorer forum (http://forum.sysinternals.com), which contains an FAQ, among other handy resources.

It's also worth taking a look at some of Sysinternals' other tools as well—Autoruns (http://bit.ly/autoruns) gives you a similarly detailed view of the start-up process, split across major tabs. It's easier to grasp than Process Explorer, and provides you with all the tools you need to streamline your startup. If you want to monitor file system, Registry, process, thread, and DLL activity in real time, then Process Monitor (http://bit.ly/processmonitor) is the tool to go for—this is particularly handy if a program is crashing, because it provides you with more detail as to where in the process things might be going wrong. Finally, RAMMap (http://bit.ly/ram-map) lets you take a peek into how your system RAM is managed.

Process Explorer Tips and Tricks



Struggling to identify a window's parent process or thread? Open Process Explorer, then drag the target-like icon next to the binoculars icon on to the window in question, and its associated thread is highlighted.

Click the binoculars icon or press Ctrl-F to open the search tool—this enables you to search by handle or DLL substring to see which processes are using (and possibly holding on to) resources. If you can't access a file because "it's open in another program," this can find what's locking it.

Choose "View → Select Columns," and you'll see you can view pretty much any kind of data about a process or thread that you want. Most useful views can be found on the "Process Image" (for additional info about the process) and "Process Performance" tabs (check "CPU History," for example, to track a process's resource consumption over time on a graph). Many of these options are overkill, but Google any terms to find out more about them. Also take the time to look at the "Handles" and "DLL" tabs—you can add extra information to both panes.

We like running Task Manager and Process Explorer together, but if Process Explorer offers all the functionality you need, you can make it your default task manager—choose "Options → Replace Task Manager." Now, pressing Ctrl-Alt-Del or right-clicking the Taskbar and choosing "Task Manager" launches Process Explorer.

Should you wish to reset Process Explorer to its defaults, right-click its system tray icon, and choose "Close Process Explorer." Press Win-R, type "regedit," and hit Enter. Navigate to "HKEY_CURRENT_USER\SOFTWARE\Sysinternals." Right-click the "Process Explorer" subkey, choose "Delete," then close Registry Editor.

Play Xbox One and PS4 Games on PC

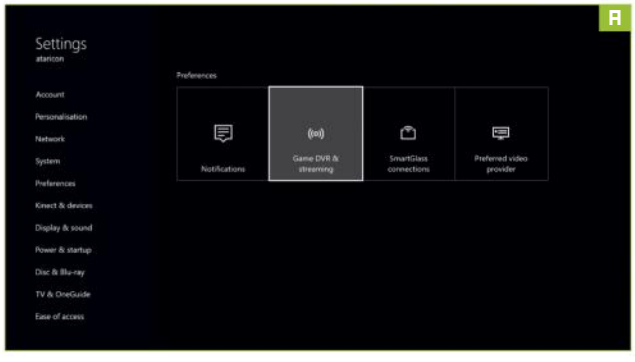
YOU'LL NEED THIS

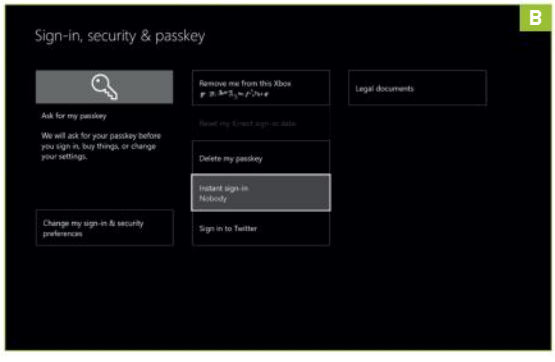
CONSOLE
You need the muscle of a current-gen box running the absolute latest firmware.

WINDOWS 10
Xbox One requires Win 10, but Win 8.1 will do the trick for PS4.

WHY, DEAR READER, should you be chained to your TV when you want to play a console game? And—sacrilegiously—why should you feel tied to the (awesome) cycle of constant upgrades your PC requires to keep up with the latest gaming standards? Maybe you've got a laptop, a supremely portable but doggedly non-upgradeable machine. What then?

Well, fear not. If you're happy with the quality of console gaming, and you've already kitted out your lounge with a modern console, you can stream your gaming to your PC, and play anywhere in the house (or, in the case of the PS4, anywhere with a fast enough Internet connection). There are even added benefits beyond the ability to game on the throne. Those expensive 360 controllers your Xbox One doesn't support? Plug them in to your PC while streaming, and they'll work just fine. That old monitor with no HDMI input? Hey, use VGA! **–ALEX COX**




B
Sign-in, security & passkey
Ask for my passkey
We will ask for your passkey before you sign in, buy things, or change your settings.
Remove me from this Xbox
Legal documents
Delete my passkey
Instant sign-in
Nobody
Change my sign-in & security preferences
Sign in to Twitter

1 HOOK IT UP

We'll concentrate on streaming the Xbox One in this main part of the tutorial—look to the right if you're streaming your PS4. But the primary step counts for both: Connect them to the finest network you can get your hands on. A wireless network barely cuts it—there's a lot of data to stream fast, particularly if you don't want your games to look like a 1999 RealPlayer video hidden behind a layer of petroleum jelly. This counts for both ends, so grab those Ethernet cables if possible, and pick up some high-end powerline networking kit if applicable.

2 XBOX ON

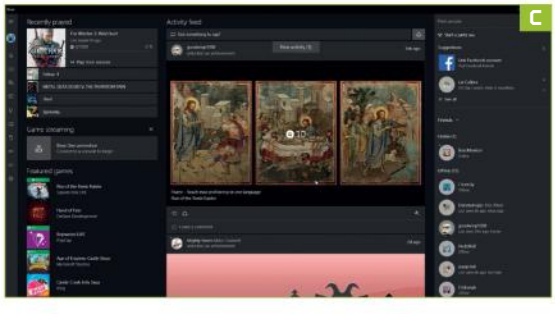
Switch on your console—hooked up to your TV for now—and make sure it's completely up to date with the latest firmware. This usually means a massive download from Microsoft's oh-so-sluggish servers, but when it's done, you'll be ready to take the necessary steps to allow streaming. In the Xbox One's left-hand vertical menu, hit the cog icon, select "All settings," and head down to "Preferences." You'll find all the options you need in the "Game DVR & streaming" menu. It's quite possible your Xbox is already configured to share itself, the promiscuous thing, but if it isn't, just tick "Allow game streaming to other devices" [**Image A**].

3 SORT SECURITY

Here's a slightly annoying thing: If you want this to work reliably without having to commandeer the TV each time you want to get started, you'll need to set your Xbox to automatically sign in to your Xbox Live account without requiring a passkey. Feel free to skip this step if you have family members who get a bit trigger-happy with your credit card, but you'll need to sign in manually each time you want to stream if you do. Go to the "Account" menu, open up the sign-in options, select "Instant sign-in," then "Use instant sign-in" [**Image B**]. Once you've done this, you'll need to switch your Xbox on to get streaming—you can do this with your wireless controller. If you really need a way to switch on your Xbox remotely, try the Python script at https://github.com/Schamper/xbox-remote-power—it's a bit beyond the scope of this tutorial.

4 APP INSTALL

Windows 10's Xbox app is—apart from being a good way to manage your Xbox Live account—the component that does the streaming on the PC end. First up, make sure it's installed by going to the Windows Store, and searching for "Xbox," as we've spotted a few early-upgrade installs of Windows 10 that don't have it on board.



Next, make sure it's fully updated, as streaming is glitchy if you don't have the latest software on either end. Finally, you'll need to launch the app and sign in to it with your Xbox Live credentials—the same credentials signed into your Xbox One. One more roadblock: If your Windows user account doesn't match these details, you may encounter problems here. If you're stuck, create a new user account using your Xbox Live login, and run the Xbox app from there.

5 CONNECT

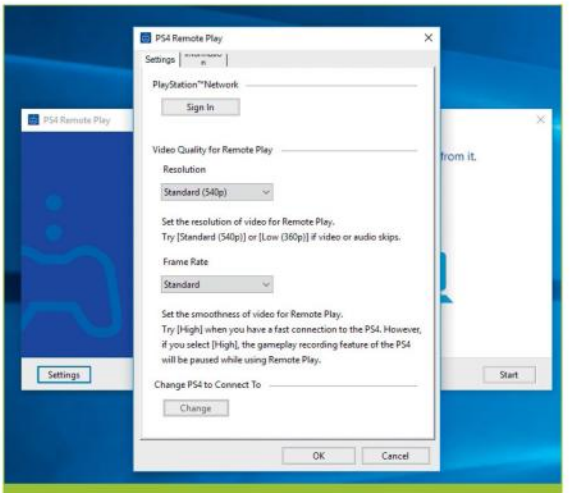
The Xbox app looks a lot like the Xbox One dashboard—confusingly so at times. Look on the left for a menu marked "Connect," and find your Xbox One in the list that appears. This synchronizes the two, giving you the option in the main menu of the Xbox app to either stream directly—which will put you in control of the Xbox One dash [**Image C**]—or just to select an installed game and stream that. Plug in an Xbox controller (or use your wireless controller, if you're close enough to your console), and you're away.

6 TROUBLESHOOTING

Here's where you're going to have to face facts about your network. If it's not up to scratch, you may see graphical glitches [**Image D**], hear audio squelches, or face the indignity of desynchronized gameplay, speeding up and slowing down as your PC struggles to catch up. If this happens to you, move your mouse to the top-right icon, and tweak the quality of streaming. You may find the lower levels acceptable, particularly given your new levels of streaming convenience.

7 TAKE IT FURTHER

Note that you don't have to stream within your house if you want to share your gameplay with the world—Twitch streaming is built into the Xbox One, and its options can be found in the "Preferences" section. Don't expect to use both streaming options at once, though, unless you're rocking some sort of extreme übernetwork. And if this has whetted your whistle, look into Steam's Remote Play features, and take advantage of that gaming rig now you know that your network can handle it.


PS4 Remote Play
Settings
PlayStation™Network
Sign In
Video Quality for Remote Play
Resolution
Standard (540p)
Set the resolution of video for Remote Play.
Try [Standard (540p)] or [Low (360p)] if video or audio skips.
Frame Rate
Standard
Set the smoothness of video for Remote Play.
Try [High] when you have a fast connection to the PS4. However, if you select [High], the gameplay recording feature of the PS4 will be paused while using Remote Play.
Change PS4 to Connect To
Change
OK
Cancel
Settings
Start

PS4 REMOTE PLAY

The PS4 has been a streaming beast for some time, piping its games to such unloved and unpurchased devices as the PlayStation TV and PlayStation Vita. As part of the April 3.5 firmware update, Sony seems to have admitted such failures, and opened its borders to streaming elsewhere, including, yes, the PC. Start by making sure your PS4 is running at least 3.5 firmware—it should have come through as an automatic update, but if it hasn't (if you have disabled automatic updates, for example), head to "Settings → System Software Update" to get it installed.

Now prepare your PC. There's not a huge system spec demand—2GB RAM, Core i5-560M—but, obviously, the better your machine is, the easier it'll cope with the demands of streaming 720p 60fps gameplay with minimal lag. Unlike the Xbox solution, Remote Play works online, so make sure you've also got a decent broadband connection—Sony recommends at least 12Mb/s. Next, head to https://remoteplay.dl.playstation.net/remoteplay/lang/gb/index.html to grab the PC client and install it.

Back on your PS4, make sure it's your primary device ("Settings → PlayStation Network → Account Management → Activate as your primary PS4"), then ensure Remote Play is activated ("Settings → Remote Play connection settings"). Return to your PC, run the Remote Play app, and sign in with the same PSN credentials you've used on your PS4. Pick your resolution (start with the highest, as you can always notch it down later), hit "Start," and you'll see your PS4 menu. Now just use a USB cable to plug a PS4 controller into your streaming device, and you should be ready to play. Try it from a remote location away from your home network, too—you may have to dial down the settings somewhat, but it should work fine.

Stream Your Gaming With XSplit

YOU'LL NEED THIS

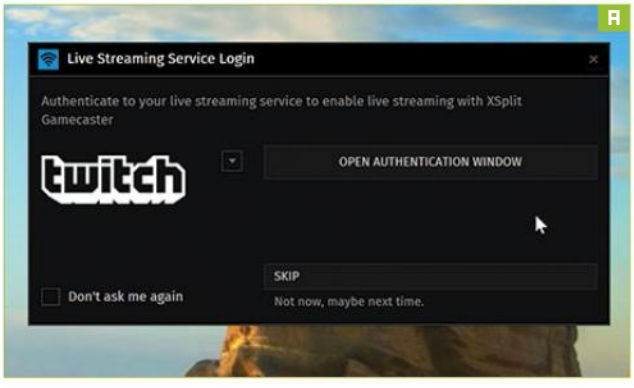
A TWITCH ACCOUNT
Register at www.twitch.tv.

XSPLIT GAMECASTER
Download from www.xsplit.com.

HEADSET, WEBCAM, PC, AND ONLINE CONNECTION
This takes a lot of CPU power.

GAME STREAMING IS A SERIOUS BUSINESS. For some people, it's actually possible (though improbable) to make a living sitting in front of your PC, thanks to the generosity of viewers, and Twitch's numerous partnership schemes. We're not here today to teach you those particular secrets, though. We're working on the most important step: getting yourself out there in a presentable, watchable manner.

It's worth mentioning here that this tutorial doesn't only work for Twitch, though that's the service most people use—you can also use XSplit Gamecaster to send your various embarrassing misplays and goofups to Hitbox, YouTube Live, and a number of other services. We'll show you how to add additional accounts. And we're working with the basic version of XSplit here; picking up a license (from $2.50 per month) will add heaps of extra features, and enable 1080p streaming without a watermark, so it's worth considering if you're picking up streaming steam. –ALEX COX


A
Live Streaming Service Login
Authenticate to your live streaming service to enable live streaming with XSplit Gamecaster
twitch
OPEN AUTHENTICATION WINDOW
SKIP
Don't ask me again
Not now, maybe next time.

1 DOWNLOAD AND INSTALL

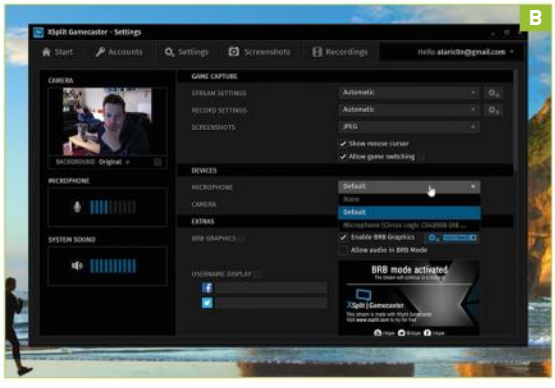
We'll begin with the obvious setup steps, and not go into huge detail because, hey, you can handle it, champ. Register a Twitch account at www.twitch.tv, register an XSplit account at www.xsplit.com, then follow the links in your email to activate these accounts. Download XSplit Gamecaster and install it—if your machine is missing any of the prerequisites it needs, it grabs them and installs them for you, so make sure you're online while you install. Run Gamecaster for the first time, and you're given the option to connect to your streaming service [Image A]. Twitch is selected by default, so click "Open Authentication Window," log in, and click the "Authorize" button to share the relevant security keys from your account with XSplit.

2 YOUR FIRST STREAM

Once Gamecaster has fully run, you're already set to pull off a basic stream—simply open your chosen game, hit Ctrl-Tab to see the XSplit overlay, then hit "Stream" to begin sending your video to Twitch. XSplit automatically works out the optimal bitrate, based on your network connection. Switch away from your game, and XSplit displays a default BRB message to your viewers—this is a limitation of the free version, so if it bugs you, you should think about upgrading.

3 HARDWARE TIMES

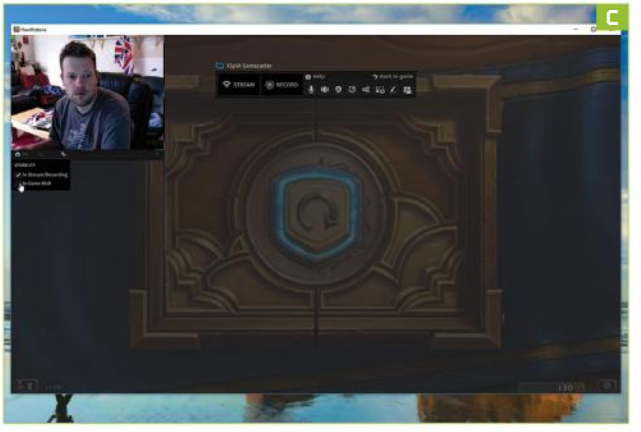
Quit your game for now (this stops the streaming automatically), and head back to the Gamecaster interface, so we can make sure it's using the correct hardware to do its thing



[Image B]. In "Settings/Devices," use the drop-down box to ensure it's using the correct microphone for your headset—we wouldn't recommend using, say, a laptop mic, just for the sake of those watching—and check that your webcam is hooked up, too. You should see a preview in the top-left of the window if it is. You can also tweak the audio levels that go out to your stream here—although, because these settings are also available through the XSplit overlay, you may be better altering them there, based on the feedback of your viewers.

4 ADD YOUR CAMERA

What would game streaming be if your viewers couldn't see the look on your face as you get destroyed for the 32nd time? It would be rubbish. Thankfully, Gamecaster makes adding a camera to your stream a trivial matter. Go back to your game (you don't have to resume streaming just yet), hit Ctrl-Tab to bring up the overlay, and click on the camera icon to plop your webcam on top of your game. Now drag the edges to resize it, and drag the center to place it where you want it, trying not to cover up anything important. It can be tough to play games with the self-conscious feedback loop caused by staring at your own face, but you can choose to have the cam only appear to stream viewers, thankfully. Hover your mouse over the bar on the edge of the webcam [Image C] and find the visibility icon, then switch off "In Game HUD" to have it only appear to stream viewers.


C

5 KEEP UP WITH CHAT

Let us flip the principle we just used to hide the webcam while playing, in order to introduce a layer that only we can see. Twitch chat, 30-second delay or not, is a vital part of staying connected to your audience, and if you're running full-screen, or don't have the luxury of multiple monitors, Gamecaster's chat overlay is vital. Open the overlay with Ctrl-Tab, hover over the Twitch icon, and click the second icon down to show the Twitch chat panel. Find the visibility icon, and this time set it to only display on the in-game HUD. It's also worth dropping the opacity of the window somewhat (take it all the way to zero to only see the chat messages), and repositioning it so it's not covering vital areas of gameplay [**Image D**]. If you want to send messages while you're playing, just open up the overlay as usual, and type into the gray box at the bottom of the chat window. Finishing your message with Shift-Enter closes the overlay automatically when you've finished typing.

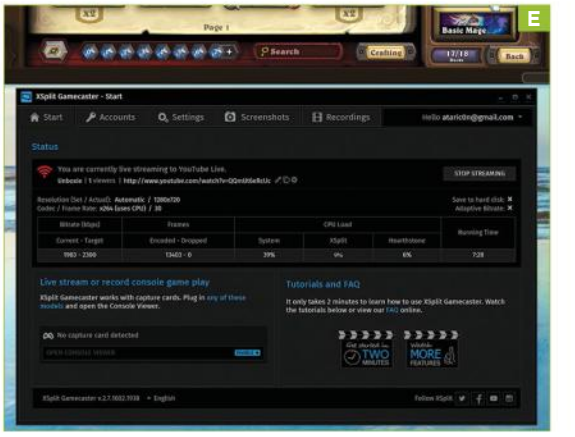
6 STREAMING PROPER

By now, you'll have your layout locked down. Just a couple of things to do: set the title of your stream, and tell people you're online. Hover over the Twitch icon, and hit the cog to customize your title—XSplit will have automatically matched up the game you're playing with a game in Twitch's extensive database. The next icon along enables you to share to Facebook and Twitter—click each icon to authorize your account, as you did with your Twitch account earlier on, then hit "Share" to send the message out.

7 MOVING HOME

Provided your YouTube account is in good standing, you can stream your gameplay via YouTube Live instead of Twitch. Head back to the Gamecaster app, go to the "Accounts" tab, and click the drop-down arrow to the right of your Twitch account. Select

D


E

"YouTube Live," and authorize the account as before. You may need to accept YouTube Live's terms of service before you can complete this step; Gamecaster gives you a link if that's the case. When you begin streaming, enter your stream info into the box provided—you can't change this on the fly as with Twitch—and be sure to change the status from "Unlisted" to "Public" if you want your channel's subscribers to see that you're streaming.

8 SEE YOUR STATUS

While streaming, keep half an eye on the "Start" tab of the Gamecaster window. It keeps you informed of your current bitrate, any dropped frames, and the load on your system from your game, XSplit, and overall [**Image E**]. If these numbers creep too high, you may need to drop your bitrate manually by going to "Settings," clicking the "Automatic" box next to "Streaming," selecting "Custom," and dialing in your own options. Happy streaming!

THE OBS ALTERNATIVE

While XSplit hides many of its features behind its subscription fees, Open Broadcaster Software (www.obsproject.com) is a free, open source way to get your footage streaming online. It's less user-friendly than Gamecaster, and there's a reason the majority of streamers favor XSplit, but OBS might be a good move before stumping up the cash. It structures itself into scenes and sources, which you need to create before you can start streaming. A single scene can contain multiple sources—images, games, webcams—and setting up multiple scenes before streaming means you can transition smoothly between them. Grab OBS Studio for the most up-to-date version; it's still in development, but it works just fine.

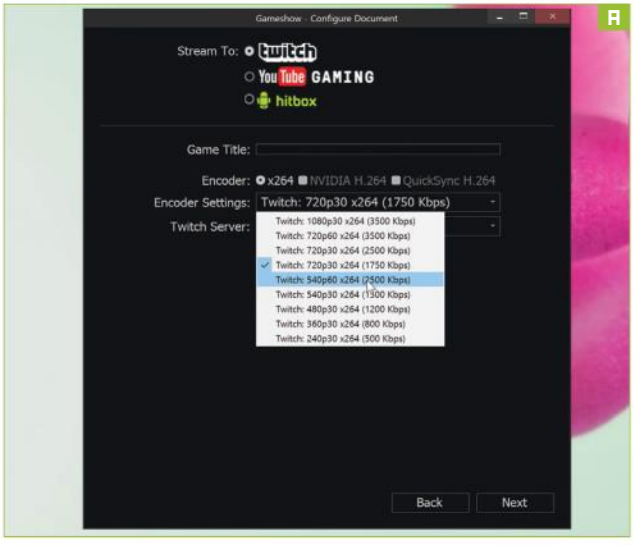
Create Pro Streams with Gameshow

YOU'LL NEED THIS

GAMESHOW
Download and try it for free from www.gameshow.net.

STREAMING ACCOUNT
Head to www.twitch.tv to sign up as a streamer.

THE STREAMING MARKET on YouTube, Twitch, Hitbox, et al is growing quickly. So quickly, in fact, that if you're not putting out a professional-looking stream, you may struggle to gain any viewers at all. This is easier said than done. Open Broadcaster Software certainly gives you the flexibility to produce a fully custom stream, but it's among the most ugly and finicky pieces of software ever created. XSplit provides a beautiful overlay and a similarly beautiful interface, but a subscription involves a not-insignificant outlay. The solution? Streaming's new kid on the block, Gameshow. It's only been around for just over a year, but the fact that it was spawned from the labs of streaming expert TeleStream makes it the perfect tool to add a professional shine to your streams. It's not free, unlike OBS, but there's a limited-resolution or watermarked trial to use to see if you like it, and the full version involves just a $29, one-time outlay for 12 months of updates. **–ALEX COX**



1 STARTER'S ORDERS

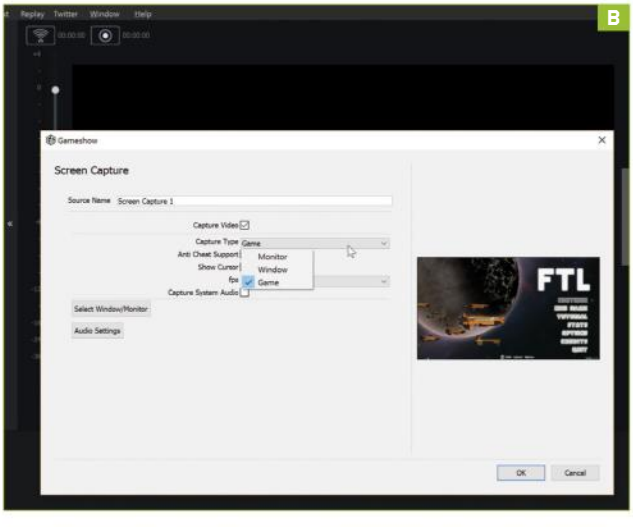
Let's start from the very beginning. Download Gameshow, install it, and run it. Skip past the release notes window, and you're given your most basic creation options. You could, if you're playing a popular game, opt for a template related to the likes of *CS:GO* or *Dota 2,* or choose one of Gameshow's pre-built generic templates, but don't. Although we're in this for an easier time, that's not going to teach you anything, and it certainly won't make your stream unique. Instead, select "Blank," then click "Next." Now click the radio button for the service you'll be streaming to, type in the title of the game you'll be streaming, and, if you have a discrete graphics card, change up the encoder from the basic x264 software encoder to something with a bit more muscle.

›› Users of the free version are stuck with a large animated watermark overlaid over any stream of 30fps 720p at 1,750Kbps or more, so drop the encoder settings down [**Image A**], unless that's something you really want, or you are a paid-up user. Streamers to anything other than YouTube should also pick the most local server here. Hit "Next," and you're asked to authorize with your streaming service of choice, which only happens on your initial setup; you won't be asked again if you create a new template in future. Just like that, you're in—and doesn't Gameshow's dark exterior look intimidating? It does. But it's a puppy inside.

2 GET THE SHOT

Let's give you a quick primer. Gameshow uses three base components to create a streaming template: shots, layers, and, er, shot layers. Shots hold your delicately composed picture elements—your webcam, game, explanation text, and the like. Because they can be reordered in any manner you choose, these elements are called shot layers. Plain ol' layers, on the other hand, enable you to slather several fully composed shots on top of one another. If you create, say, a stream overlay shot in the top layer, with your branding smeared all over it, and put a nice background shot in the bottom layer, you can easily flick through several shots on the middle layer without affecting these in the slightest.

›› We'll start by creating the most basic of shots. So, fire up a game—absolutely any game will work for this—and make sure that it's running, ideally in a window or on a second monitor, so you can still see Gameshow. You'll see, in the bottom portion of Gameshow's main interface, that you have one blank shot at the moment, in the middle layer. This should be highlighted, and it's the one you're about to make changes to. In the left-hand column, click the plus button, then click "Screen capture" to tell Gameshow you want to capture something. This is a slight



SOUND ADVICE

Great sound is absolutely critical for online streaming—some say even more so than a great picture. While Gameshow's primary focus is on making awesome-looking streams, it's adept at improving your audio, too. Your individual shot layers can be muted or unmuted by clicking the speaker icon next to them, or you can click a shot layer, then hit the speaker icon above, to alter individual volumes and pans. Clicking the headphone icon below any of the vertical meters enables you to monitor what sounds are coming out (useful for checking your mic before you stream), and you have access to quick volume controls if anything starts to hit the red.

The meat of Gameshow's audio tweaks, though, are found in the Audio Mixer, which you can bring up by hitting Ctrl-U. Activate a shot with, say, your microphone in it, and that element

appears here. You can then add various equalizing and boosting effects, or alter the balance of your audio to ensure you can be heard over your blaring game.

misnomer, because this option enables you to capture a full screen, a window, or—as you're now able to do by changing the capture type appropriately—a game. Click "Select Window/Monitor," deselect "Capture any full screen game," then select your game's process in the upper drop-down box. Hit "OK," and the game's content, minus any ugly window borders, should appear in the preview window [**Image B**]. Hit "OK" once more, and your game now appears front-and-center in your shot.

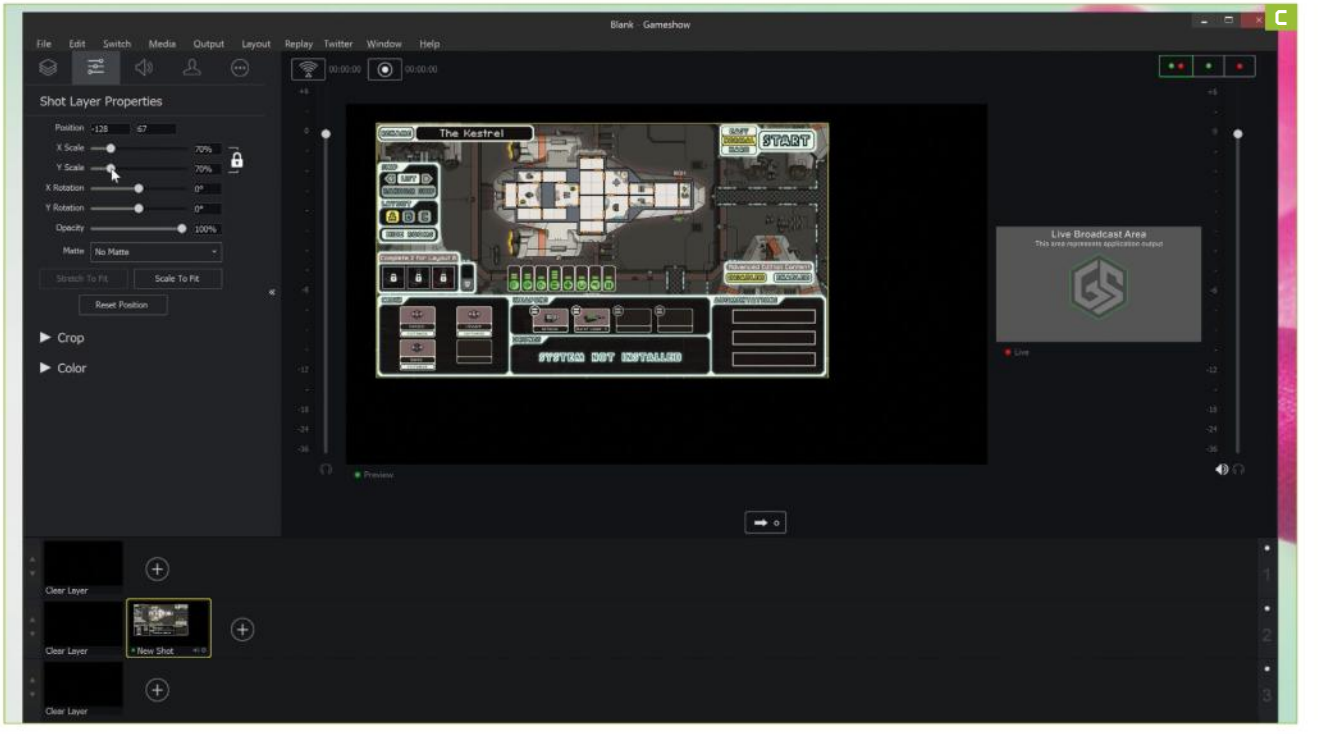
3 FACE TIME

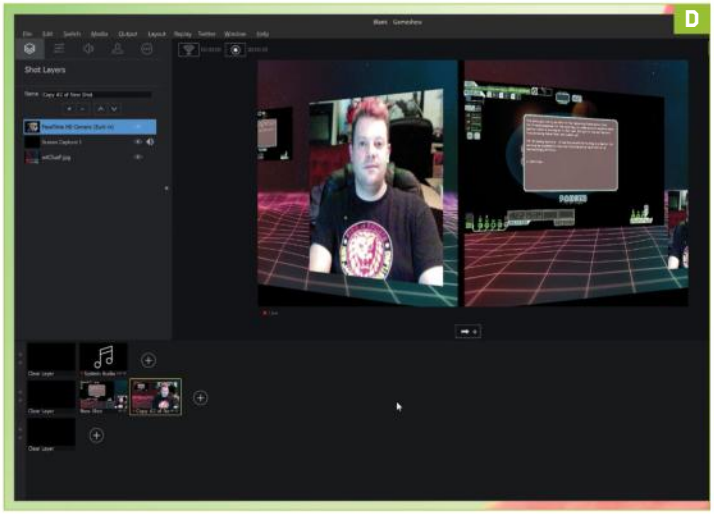
What streamer worth their salt would omit a good old facecam from proceedings? Presuming you've got a webcam hooked up and pointing at your visage, this is a trivial matter: Just add a new element to your shot as before, but this time select "Capture devices," and then your webcam. Here's where things get a bit more tricky, though. For one, that camera is now going to be obscuring some of the game. And if you're anything like us, it's also going to be capturing the strewn detritus of a particularly disorganized office. Time to make use of Gameshow's Properties panel to set things right. First, click your game capture layer in the left column, then click the slider icon above. Dragging the scale sliders [**Image C**] enables you to resize the game to your liking, and you can click and drag it in the central shot composition window to place it exactly where you want it.

›› Now head back to the shot layers section, and select your webcam. Back in the Properties panel, scroll to the bottom, and expand the Crop menu. You can use these sliders to trim away the abandoned chip bags and dirty plates, and then resize and reposition your webcam as you did before.

4 ALL THE ELEMENTS

If you were to start your stream now (by clicking the broadcast icon, at the top-left of the shot composition window), your viewers wouldn't get a very good show. In fact, they would see what's currently in the live view on the right-hand side—a boring gray screen. This is down to the way Gameshow handles its output; you can compose shots and make tweaks on the fly, but a shot, or any changes you've made to it, aren't (by default) broadcast until you explicitly make it so by selecting it and hitting the Space bar. This is super-handy for maintaining





a professional appearance, but something you'll have to remember to do as you stream.

›› Even if your shot had gone live, your viewers still wouldn't be getting a very good show, as you're broadcasting with no audio. You can add different audio sources to different shots, but this is a good opportunity to make use of a layer to ensure your system audio is audible, no matter what shot is live. In the uppermost layer, click the plus button to create a new shot, and select "Capture Devices → System Audio Capture." Bear in mind this grabs any sound your machine makes, not just that of the game, which is perfect if you want to involve chums on Discord or Skype, but less neat if Windows 10 is going to shout at you with repeated noisy pop-ups, so make sure your Windows notifications are all switched off. You also have no microphone audio at this point. We'll leave adding this particular shot layer as a little exercise for you—if you're going to create, for example, a BRB shot, you may wish to add it to individual shots on the central layer, rather than having it active at all times.

5 SHOT FOR SHOT

Gameshow is adept at transitioning between different shots, so let's try that now. Right-click your shot in the lower portion of the interface, and select "Duplicate shot." Change the copy by using the shot layer properties controls to make your webcam bigger and your game smaller, then hit the red dot button at the top-right of the Gameshow window to see only the live view. Switch to your new shot by highlighting it and hitting Space, and you'll see the components smoothly resize themselves; switch back using the same process, and you'll see the opposite happen.

›› You can create more complex transitions between shots using the Switch menu on the main menu bar. Select your choice of an immediate cut, a smooth transition (which is what we've been using so far), or one of a number of fancy dissolves and wipes [**Image D**]. Note the "Go" option at the top of the menu—using Space still pulls off the old smooth transition; if you want to use your new one, either select "Go," or hit Ctrl-G. Alternatively, and this basically does away with the "compose your shot before it goes live" deal, you can switch on AutoLive in the Switch menu, which changes shots, using your fancy transition, as soon as you click on them. If you're going to use this, make sure you've planned out your stream, and composed all the shots you need, before going live.

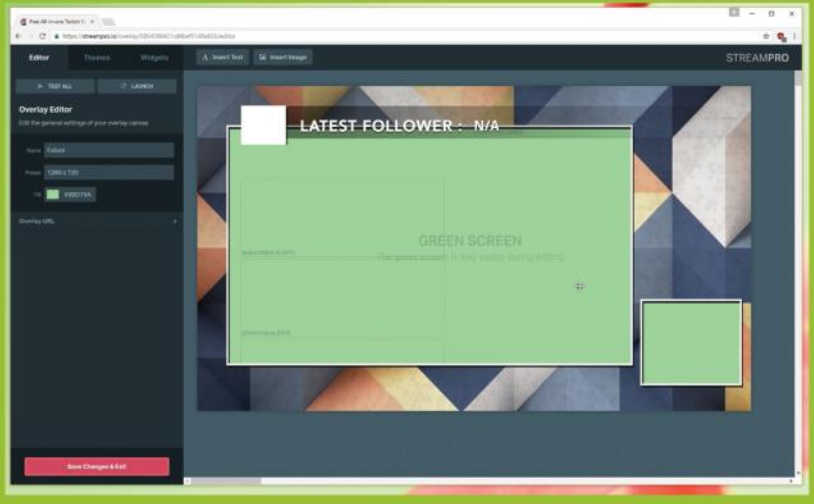
6 STREAM AWAY

Now would be a good time to test your stream, and the only way you can really do this is by going live. There's a broadcast icon at the top-left of the preview window; click this, and you start sending your stream to the Internet. Keep an eye on the stats that now pop up. They let you know the bitrate you're broadcasting at, the amount of CPU power your stream is draining, the number of viewers your stream currently has, and, importantly, the number of frames you've dropped. If you start dropping a lot of

MORE ELEMENTS

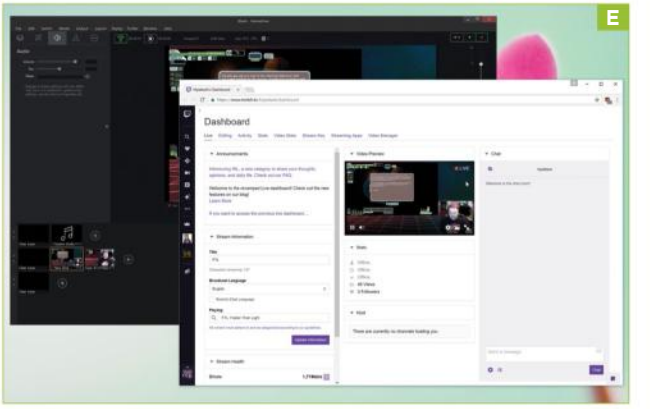
You can add just about anything to your Gameshow streams. We've discussed media files, a category that covers images, videos, and audio. Then there are screen captures, encapsulating windows, monitors, and games. You can also add text boxes, either static or drawn from an RSS feed, and make them scroll if you wish. You can pull in your Twitch chat, giving your viewers a chance to see their carefully chosen words (or hastily typed Kappas) on the stream itself. There's a social media widget, which is a quick way to publicize your social feeds, as well as a live Twitter layer, which compiles your latest tweets. You can even run donation drives, as long as you're signed up with imraising.tv and have an API key.

If your desired layer isn't in the long list of included options, it could be time for a little improvisation on your part. Twitch users, for instance, should head over to www.streampro.io and link their Twitch account to the StreamPro service. You can then create your very own custom overlay, and include a whole host of live information. Copy its overlay URL, then go back to Gameshow, and add a new "web display" shot layer, pasting the URL into the appropriate box to see your chosen design pasted on top of your regular stream.



frames, look for potential issues with your Internet connection, or drop your bitrate ("Output → Output Settings") to the point where your broadband connection can handle it properly.

›› While you're streaming, it's a good idea to keep an eye on your Twitch (or YouTube, or Hitbox) dashboard [**Image E**], reachable via the Output menu, to ensure you've titled your video correctly, and to keep an eye on chat. Professionalism in presentation is one thing, but you need a keen eye on your audience if you want to keep them coming back. As we're only testing, though, it may be a good idea to cast an eye over your stream to make sure everything's coming out as you expect. Listen to the audio—if there are problems, follow the steps in the "Sound Advice" box, pg. 61, to fix them. Watch the video, and check your transitions—this is where you'll understand exactly what you're doing wrong.



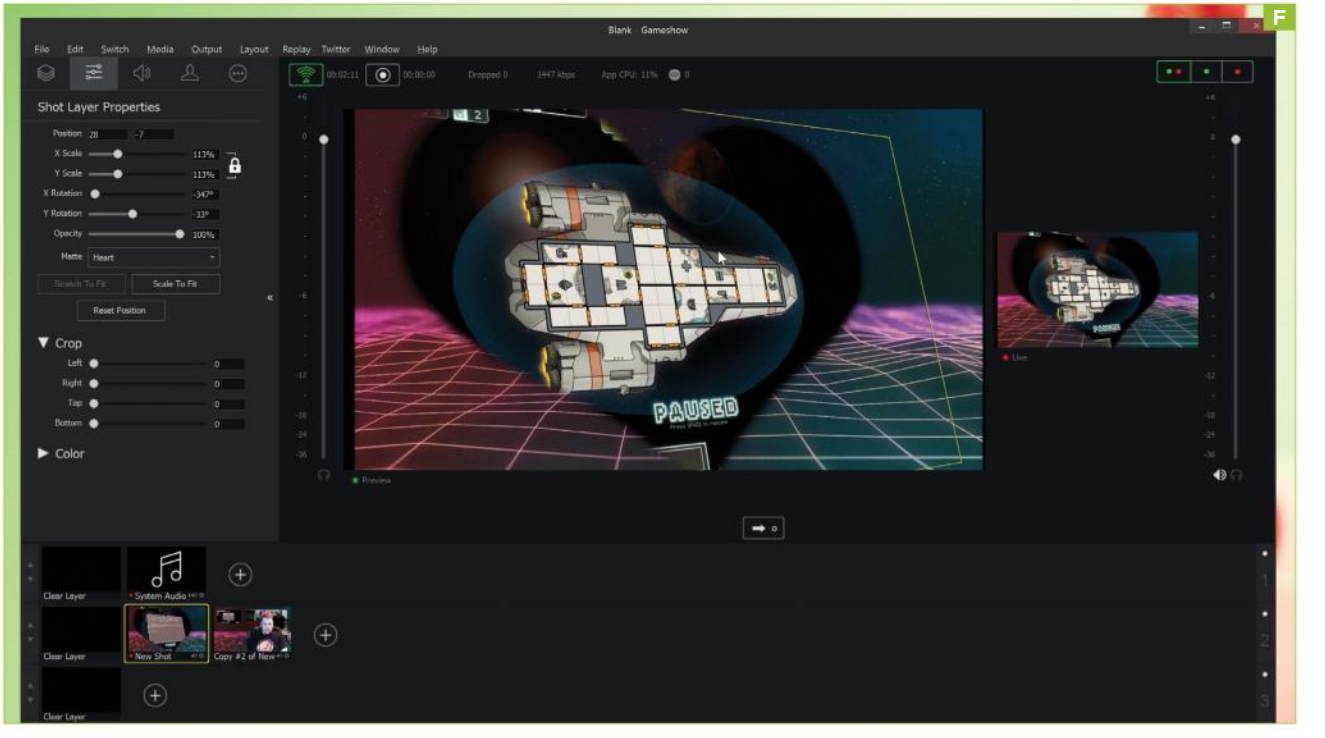
7 ADDING FLOURISHES

With a test stream out of the way, now's the time to start delving further into Gameshow's features to see what else you can do. Visual shot layers—game capture, webcams, any videos you might have added in—can be manipulated beyond scaling and cropping. Try tweaking the X and Y rotation to put these elements on a wacky angle, for instance. This isn't recommended for the main focus of your footage, but might be a nice effect for your webcam. You can also add mattes, trimming or blurring the edges of your shot layers, and while the built-in options aren't particularly good—unless you want your game surrounded by a cartoon heart [**Image F**] or a silly spiky edge—you can import your own images as custom mattes.

›› The more pallid among us may wish to tweak the color options, too. Boosting the saturation and contrast can make a big difference to the output of poor webcams, and there's a handy reset button if you happen to leave yourself looking like a diseased alien. If you're lucky enough to be sitting in front of a brightly colored background, you can also use Gameshow's built-in chroma key options to mask it out altogether. Click the head-and-shoulders icon to bring them up, switch chroma key on with the appropriate checkbox, check the box that lets you pick the key color, and click in your preview to isolate your background. There may be a fair amount of slider tweaking required before you get brilliant results, and bear in mind that this is chroma key, rather than color key, which means it can only remove bright colors, not whites or blacks.

8 FINISHING TOUCHES

You're pretty much familiar with the basics of Gameshow now, so let's go about tidying up your stream layout with a final spit and polish. Add in a background on the bottommost layer (to go behind your game and webcam) by creating a 16:9 image in your favorite arty program, and adding a new "media file" shot layer. Now create yourself a BRB shot in the uppermost layer, for when you're away from your PC, or getting your stream set up. Create a new shot (ideally, this time, without your system audio or microphone input attached), add an image by adding a media file as before, and—hey, why not?—add some royalty-free music, too. It's added in the same way as you would add an image, and is set to automatically loop while the shot is active. Happy streaming!



Connect Securely with OpenVPN

YOU'LL NEED THIS

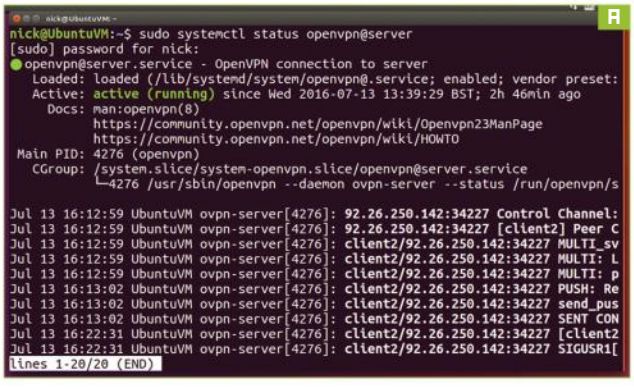
DYNAMIC DNS ADDRESS
Get a free one from NoIP (www.noip.com/free) and point your client at that.

UFW FIREWALL
Visit https://bit.ly/openvpn-ufw for the steps you need to follow to configure it (substitute `nano` for `vim` in the instructions).

JUST HOW SECURE IS YOUR INTERNET CONNECTION? The answer is often "not very." One of the most dangerous places to surf the web or check your email is via a public Wi-Fi hotspot. What you need is a guaranteed form of encryption to keep your business private, and that's where a virtual private network (VPN) comes in.

VPNs are designed to add an extra layer of security to the Internet and other public networks. They basically create a secure "tunnel," inside which all your data is encrypted before being sent over the network. Their main use for home users is to provide a secure connection to the Internet, even over insecure networks. Commercial VPN services offer free packages, but these are slow and limited.

A much better option is to add your own VPN to your Ubuntu computer for free. Thanks to OpenVPN, you can set up your own server, then configure it to provide one or more devices (mobile or computer) with a secure on-demand VPN whenever it's required. Without further ado, then, let's get started. **–NICK PEERS**


nick@UbuntuVM:~$ sudo systemctl status openvpn@server
[sudo] password for nick:
openvpn@server.service - OpenVPN connection to server
Loaded: loaded (/lib/systemd/system/openvpn@.service; enabled; vendor preset:
Active: active (running) since Wed 2016-07-13 13:39:29 BST; 2h 46min ago
Docs: man:openvpn(8)
https://community.openvpn.net/openvpn/wiki/Openvpn23ManPage
https://community.openvpn.net/openvpn/wiki/HOWTO
Main PID: 4276 (openvpn)
CGroup: /system.slice/system-openvpn.slice/openvpn@server.service
└4276 /usr/sbin/openvpn --daemon ovpn-server --status /run/openvpn/s
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: 92.26.250.142:34227 Control Channel:
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: 92.26.250.142:34227 [client2] Peer C
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 MULTI_sv
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 MULTI: L
Jul 13 16:12:59 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 MULTI: p
Jul 13 16:13:02 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 PUSH: Re
Jul 13 16:13:02 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 send_pus
Jul 13 16:13:02 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 SENT CON
Jul 13 16:22:31 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 [client2
Jul 13 16:22:31 UbuntuVM ovpn-server[4276]: client2/92.26.250.142:34227 SIGUSR1[
lines 1-20/20 (END)

1 GETTING STARTED

The following tutorial works with your basic Ubuntu 16.04 install, and should happily run on 16.10 or 17.04—the only real requirement is that your PC is on and connected to the Internet at home whenever you want to employ your VPN's services abroad.

» First, let's install OpenVPN Server. Although it's part of the official Ubuntu repositories, you can't install it through Software Center, so open a Terminal window, and type the following:

```
$ sudo apt-get update
$ sudo apt-get install openvpn easy-rsa
```

» This installs two packages—the latter (easy-rsa) sets up and manages the certificates required to encrypt your network traffic. The easy-rsa package allows you to use OpenVPN in a PKI (Public Key Infrastructure), which consists of public and private keys for each server and client, with the public keys being used to identify trusted clients and servers to each other. These public keys are signed using certificates to verify their identity, and your server needs to be configured as a Certificate Authority (CA) to create, distribute, and manage these certificates.

» First job, then, is to set up your CA, and build the server's private and public keys—check out the step-by-step guide opposite for details. Once that process is complete, it's a good idea to "harden" your VPN's security further with the following Terminal commands:

```
$ cd ~/openvpn-ca
$ ./build-dh
$ openvpn --genkey --secret keys/ta.key
```

2 CONFIGURE OPENVPN SERVER

Now it's time for the nitty-gritty: configuring your OpenVPN Server, and getting it up and running. First, you need to copy the encryption keys and other files you've just created to the "/etc/openvpn" directory, again using the Terminal:

THE MAKE_CONFIG.SH SCRIPT

Open up a Terminal, and then type the following command in order to create an empty file:

```
$ nano ~/openvpn-ca/client-configs/make_config.sh
```

Now you need to carefully enter the following lines:

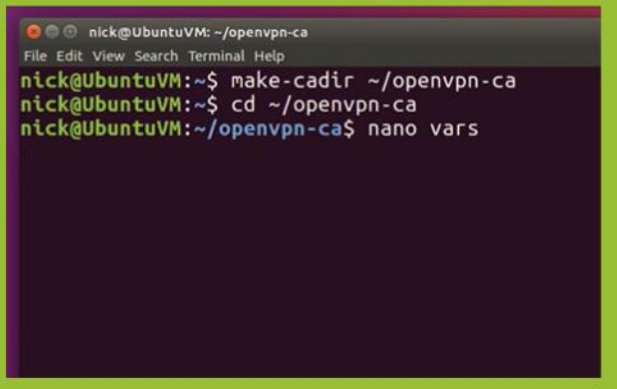
```
#!/bin/bash
# First argument: Client identifier
KEY_DIR=~/openvpn-ca/keys
OUTPUT_DIR=~/openvpn-ca/client-configs/files
BASE_CONFIG=~/openvpn-ca/client-configs/client.conf

cat ${BASE_CONFIG} \
    <(echo -e '<ca>') \
    ${KEY_DIR}/ca.crt \
    <(echo -e '</ca>\n<cert>') \
    ${KEY_DIR}/${1}.crt \
    <(echo -e '</cert>\n<key>') \
    ${KEY_DIR}/${1}.key \
    <(echo -e '</key>\n<tls-auth>') \
    ${KEY_DIR}/ta.key \
    <(echo -e '</tls-auth>') \
    > ${OUTPUT_DIR}/${1}.ovpn
```

Once created, save and close the file, before typing the following command to make it executable:

```
$ chmod 700 ~/openvpn-ca/client-configs/make_config.sh
```

SET UP YOUR CERTIFICATE AUTHORITY



GNU nano 2.5.3 File: vars Modified
These are the default values for fields
which will be placed in the certificate.
Don't leave any of these fields blank.
export KEY_COUNTRY="UK"
export KEY_PROVINCE="Essex"
export KEY_CITY="Colchester"
export KEY_ORG="Nick-Peers"
export KEY_EMAIL="nick@nickpeers.com"
export KEY_OU="MyVPN"
X509 Subject Field
export KEY_NAME="MyVPN"
PKCS11 Smart Card
export PKCS11_MODULE_PATH="/usr/lib/changeme.so"
export PKCS11_PIN=1234
If you'd like to sign all keys with the same Common Name, uncomment the KEY_CS
You will also need to make sure your OpenVPN server config has the duplicate-S
Get Help Write Out Where Is Cut Text Justify Cur Pos
Exit Read File Replace Uncut Text To Spell Go To Line

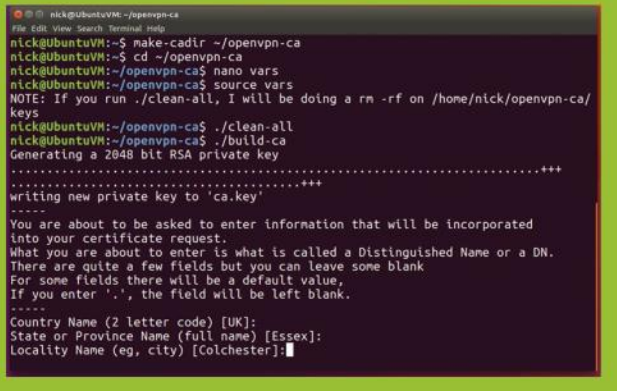
1. SET UP CERTIFICATE AUTHORITY DIRECTORY

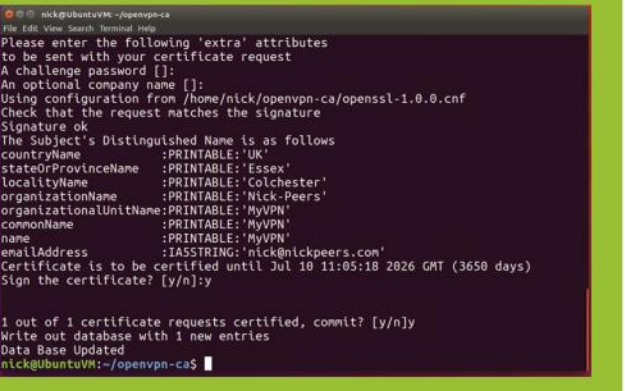
First, you need to copy the easy-rsa template directory to your home directory, so your custom certificates aren't overwritten when the package is updated. So, open the Terminal and type the following:

```
$ make-cadir ~/openvpn-ca
$ cd ~/openvpn-ca
$ nano vars
```

2. EDIT VARS FILE

Scroll down to the group of lines beginning "export KEY_COUNTRY," and fill them in with your own personal information—see the screenshot for an example. Note "KEY_PROVINCE" should be filled with the state, such as "Mississippi" or "California." Put your name or organization in "KEY_ORG," and fill "KEY_OU" and "KEY_NAME" with whatever you like, such as "MyVPN." Save the file (Ctrl-O) and exit.


nick@UbuntuVM:~$ make-cadir ~/openvpn-ca
nick@UbuntuVM:~$ cd ~/openvpn-ca
nick@UbuntuVM:~/openvpn-ca$ nano vars
nick@UbuntuVM:~/openvpn-ca$ source vars
NOTE: If you run ./clean-all, I will be doing a rm -rf on /home/nick/openvpn-ca/keys
nick@UbuntuVM:~/openvpn-ca$ ./clean-all
nick@UbuntuVM:~/openvpn-ca$ ./build-ca
Generating a 2048 bit RSA private key
writing new private key to 'ca.key'
You are about to be asked to enter information that will be incorporated into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
Country Name (2 letter code) [UK]:
State or Province Name (full name) [Essex]:
Locality Name (eg, city) [Colchester]:


Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []:
An optional company name []:
Using configuration from /home/nick/openvpn-ca/openssl-1.0.0.cnf
Check that the request matches the signature
Signature ok
The Subject's Distinguished Name is as follows
countryName :PRINTABLE:'UK'
stateOrProvinceName :PRINTABLE:'Essex'
localityName :PRINTABLE:'Colchester'
organizationName :PRINTABLE:'Nick-Peers'
organizationalUnitName:PRINTABLE:'MyVPN'
commonName :PRINTABLE:'MyVPN'
name :PRINTABLE:'MyVPN'
emailAddress :IA5STRING:'nick@nickpeers.com'
Certificate is to be certified until Jul 10 11:05:18 2026 GMT (3650 days)
Sign the certificate? [y/n]:y
1 out of 1 certificate requests certified, commit? [y/n]y
Write out database with 1 new entries
Data Base Updated
nick@UbuntuVM:~/openvpn-ca$

3. BUILD CERTIFICATE AUTHORITY

At the Terminal, verify you're still in the openvpn-ca directory, then type: "source vars" and hit Enter. You should see a "NOTE" appear (see screenshot). Now type "./clean-all" and hit Enter, followed by "./build-ca" and hit Enter. You're taken through the root certificate authority key and certificate. Hit Enter when prompted to confirm each edit you made in the previous step.

4. GENERATE SERVER'S KEYS

Type "./build-key-server MyVPN" and hit Enter, replacing "MyVPN" with the value you entered for "KEY_NAME" in step 2. Hit Enter to accept the default choices as before. When prompted to create a challenge password, hit Enter to leave it blank, and hit Enter again when prompted for an optional company name. Complete the process by pressing Y to the last two prompts.

```
$ cd ~/openvpn-ca/keys
$ sudo cp ca.crt ca.key MyVPN.crt MyVPN.key ta.key dh2048.pem /etc/openvpn
```

» Replace `MyVPN.crt` and `MyVPN.key` with the value you allocated to `KEY_NAME` in the walkthrough above. Next, you need to generate your OpenVPN configuration file:

```
$ cd /usr/share/doc/openvpn/examples/sample-config-files
$ sudo cp server.conf.gz /etc/openvpn
$ sudo gzip -d /etc/openvpn/server.conf.gz
```

» Now follow the second step-by-step guide (over the page) to configure your server for basic usage. Once done, you need to perform one critical step to allow your clients to actually access the Internet through your VPN. First, enter the following command:

```
$ ip route | grep default
```

» Make a note of the interface listed next to "dev"—on our machine, this is "enp0s3." Now enter the following command, substituting `enp0s3` with the interface listed on your PC, if applicable:

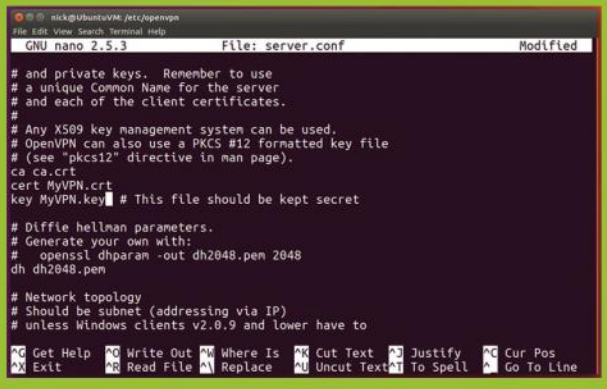
```
$ sudo iptables -t nat -A POSTROUTING -s 10.8.0.0/24 -o enp0s3 -j MASQUERADE
```

3 START AND TEST YOUR SERVER

It's time to get things up and running. Type the following Terminal command, which launches OpenVPN using the server.conf file you've configured:

```
$ sudo systemctl start openvpn@server
```

CONFIGURE YOUR SERVER


nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help
GNU nano 2.5.3 File: server.conf Modified
and private keys. Remember to use
a unique Common Name for the server
and each of the client certificates.
#
Any X509 key management system can be used.
OpenVPN can also use a PKCS #12 formatted key file
(see "pkcs12" directive in man page).
ca ca.crt
cert MyVPN.crt
key MyVPN.key # This file should be kept secret
Diffie hellman parameters.
Generate your own with:
openssl dhparam -out dh2048.pem 2048
dh dh2048.pem
Network topology
Should be subnet (addressing via IP)
unless Windows clients v2.0.9 and lower have to
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line

nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help
GNU nano 2.5.3 File: server.conf
to help block DoS attacks and UDP port flooding.
#
Generate with:
openvpn --genkey --secret ta.key
#
The server and each client must have
a copy of this key.
The second parameter should be '0'
on the server and '1' on the clients.
tls-auth ta.key 0 # This file is secret
key-direction 0
Select a cryptographic cipher.
This config item must be copied to
the client config file as well.
;cipher BF-CBC # Blowfish (default)
;cipher AES-128-CBC # AES
;cipher DES-EDE3-CBC # Triple-DES
[Wrote 305 lines]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line

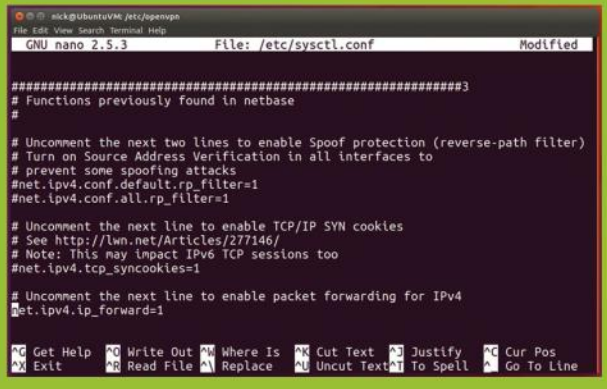
1. DEFINE SERVER KEYS

Open the configuration file you've just created using `sudo nano /etc/openvpn/server.conf` at the Terminal. We're going to focus on the bare minimum settings required to get your server up and running. Start by scrolling down to the "# SSL/TLS root certificate..." section, and changing the "cert server.crt" and "key server.key" lines to point to the files you created in step four of the previous walkthrough.

2. IMPLEMENT EXTRA ENCRYPTION

Now press Ctrl-W, and type "tls-auth"—you're taken to a line marked ";tls-auth ta.key 0." Remove the semi-colon from the beginning of this line (a process known as uncommenting) to enable it. Now add the following line underneath it, as shown in the screenshot above: "key-direction 0"—this ensures that the extra TLS authentication that you set up earlier is enabled for OpenVPN.

nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help
GNU nano 2.5.3 File: server.conf Modified
If enabled, this directive will configure
all clients to redirect their default
network gateway through the VPN, causing
all IP traffic such as web browsing and
and DNS lookups to go through the VPN
(The OpenVPN server machine may need to NAT
or bridge the TUN/TAP interface to the internet
in order for this to work properly).
push "redirect-gateway def1 bypass-dhcp"
Certain Windows-specific network settings
can be pushed to clients, such as DNS
or WINS server addresses. CAVEAT:
http://openvpn.net/faq.html#dhcpcaveats
The addresses below refer to the public
DNS servers provided by opendns.com.
push "dhcp-option DNS 208.67.222.222"
push "dhcp-option DNS 208.67.220.220"
[Search Wrapped]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line


nick@UbuntuVM: /etc/openvpn
File Edit View Search Terminal Help
GNU nano 2.5.3 File: /etc/sysctl.conf Modified
##3
Functions previously found in netbase
#
Uncomment the next two lines to enable Spoof protection (reverse-path filter)
Turn on Source Address Verification in all interfaces to
prevent some spoofing attacks
#net.ipv4.conf.default.rp_filter=1
#net.ipv4.conf.all.rp_filter=1
Uncomment the next line to enable TCP/IP SYN cookies
See http://lwn.net/Articles/277146/
Note: This may impact IPv6 TCP sessions too
#net.ipv4.tcp_syncookies=1
# Uncomment the next line to enable packet forwarding for IPv4
net.ipv4.ip_forward=1
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line

3. CONFIGURE WEB DIRECTION

These next tweaks instruct all connected clients to route their web traffic through the VPN. Press Ctrl-W to locate "redirect-gateway," and uncommon the line it's on: "push...." Uncomment the next two instances of "push" referring to DNS servers, as shown above. Finally, search for "nobody," and uncomment the "user nobody" and "group nogroup" lines. Save and exit.

4. ENABLE IP FORWARDING

Type `sudo nano /etc/sysctl.conf` and uncomment out the following line by removing the preceding # symbol from it: "#net.ipv4.ip_forward=1." Save and exit, then type the following command to reload sysctl: `sudo sysctl -p`. You should see "net.ipv4 ip_forward =1" appear, indicating the setting has been correctly applied. That's it!

›› Now check the server is running correctly:

```
$ sudo systemctl status openvpn@server
```

›› You should see a list of messages appear on screeen, including the all-important "active (running)" message [**Image A**], along with "Initialization sequence completed" at the bottom—press Ctrl-C to interrupt the status check. Next, check that the OpenVPN interface is available:

```
$ ip addr show tun0
```

›› If it shows a configured interface ending with "valid_lft forever preferred_lft forever," things should be working correctly. You can now configure OpenVPN to launch automatically at startup with the following line:

```
$ sudo systemctl enable openvpn@server
```

4 MAKE CLIENT CONFIGURATION EASY

The simplest way to configure your client is through the use of specially made .ovpn files, inside which the required key files are embedded, along with the settings needed to connect. These are created on your server, and here's what you need to do.

›› Create a directory structure inside which your client configuration files are stored, then lock down the directory permissions, and create a base config file to work from:

```
$ mkdir -p ~/openvpn-ca/client-configs/files
$ chmod 700 ~/openvpn-ca/client-configs/files
```

›› Now open the Nautilus file manager, click the "Computer" link on the left, and browse to /usr/share/

SET UP YOUR CLIENT

You can access your OpenVPN server through a variety of platforms—there's an official client for Windows, Android, and iOS (visit www.openvpn.net for details), while MacOS users can use Tunnelblick (www.tunnelblick.net). Transferring the .opvn configuration file varies from device to device: you can simply copy the file to C:\Program Files\OpenVPN\config in Windows, for example, or double-click it to import it into Tunnelblick on MacOS.

If you're running an Ubuntu client, you can install some additional packages and manage your connection through the GUI-friendly Network Manager. Open Terminal and type the following:

```
$ sudo apt-get update
$ sudo apt-get install network-manager-openvpn-gnome
```

Once installed, open the Network Manager from the menu bar, select "Edit Connections," then click "Add." Choose "Import a saved VPN configuration..." from the drop-down menu, and click "Create." Select your .ovpn file, and click "Open," then verify the settings are correct across the four tabs (click "Advanced → TLS Authentication tab" to confirm it's also recognized the TLS key). Give your connection a more suitable name—the name you assigned your VPN under KEY_NAME, say—and click "Save."

Once done, connect through the Network Manager's VPN submenu—you should see a lock appear over the menu bar's icon, indicating the connection has successfully been made. The final step is to open your browser to verify the connection works.

doc/openvpn/examples/sample-config-files/. Copy the client.conf file from here to ~/openvpn-ca/client-configs. Double-click the copied file to edit it in gedit [Image B]. First, locate the line marked `remote my-server-1 1194`, and change this to point toward your server's public IP address or dynamic DNS name—for example, `remote 1.2.3.4 1194` or `remote dynamic.ddns.net 1194`.

›› Next, uncomment both `;user nobody` and `;group nogroup`, before commenting out the lines `ca ca.crt`, `cert client.crt`, and `key client.key`, because they're added by the batch file. Last, but not least, add the following line beneath `;tls-auth ta.key 1` (which should remain commented out): `key-direction 1`. Save and exit, then follow the instructions in the box on page 64 to create the make_config.sh file, which you'll use to generate the client configuration files whenever they're needed for each client.

5 GENERATE A CLIENT CONFIGURATION FILE

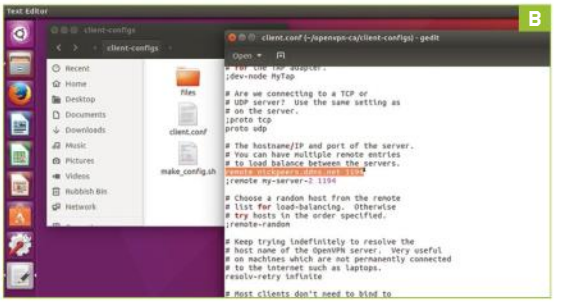
You've now got all the tools you need to create your client configuration files. Here's the process you need to follow in order to build them. First, you need to generate a certificate and key for your client using the following two commands:

```
$ cd ~/openvpn-ca && source vars
```

›› This time, ignore the note—we don't want to clean anything—and then type:

```
$ ./build-key client1
```

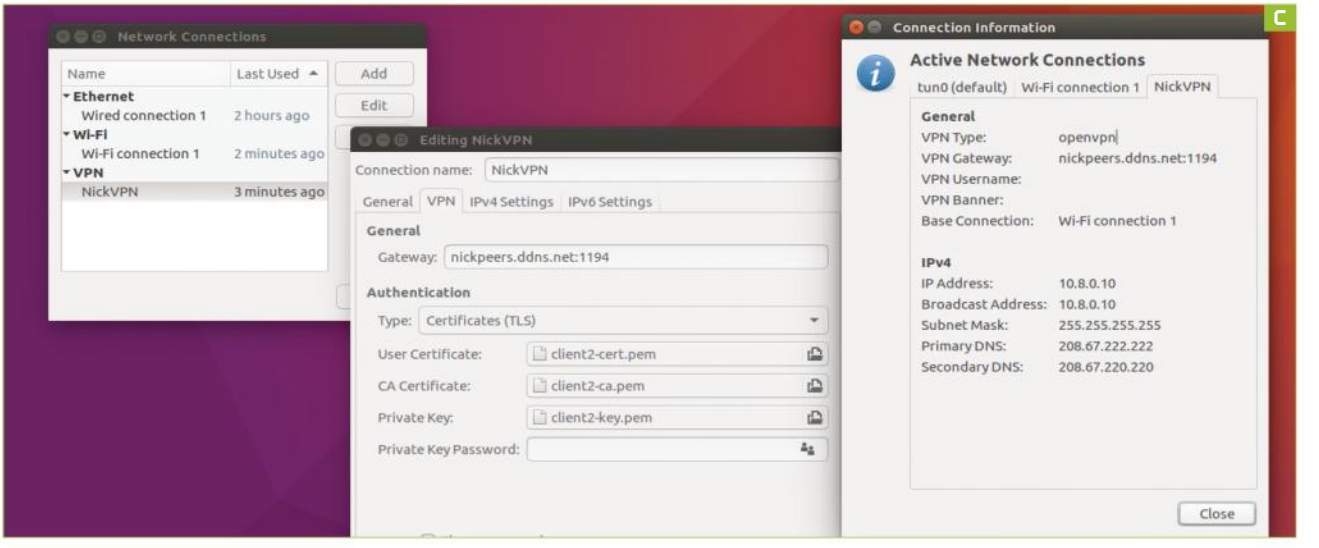
›› You need a unique name for each client certificate you generate—so, for subsequent certificates, you would use `client2`, `client3`, and so on. Again, you're taken through a similar process as when you ran the build-server-key command, and the answers are exactly the same—no challenge password, and accepting the default choices.



›› Once generated, build the configuration file:

```
$ cd client-configs
$ ./make_config.sh client1
```

›› You'll find a file marked client1.ovpn inside the client-configs/files subfolder. This now needs to be securely transferred to your client—the box above reveals the different options available to you, and how to configure a VPN connection to your server from another Ubuntu PC. Congratulations—you've just made your Internet connection more secure [Image C].



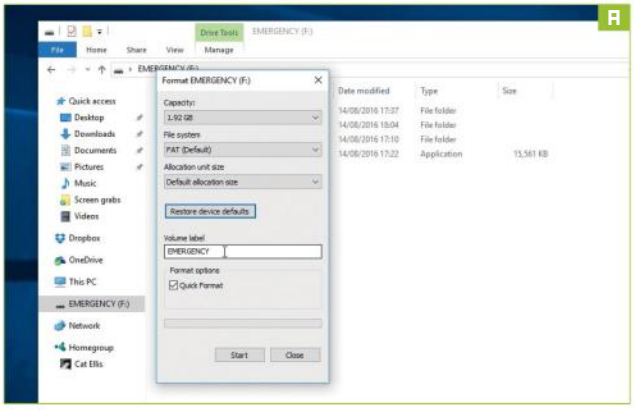
Make a USB Stick Emergency Toolkit

YOU'LL NEED THIS

USB STICK
We recommend using a USB stick about 1GB in size.

VIRUSES, MALWARE, ACCIDENTAL DELETION, or corrupted data can all put your valuable files at risk. The best insurance is to make regular backups, but what if you run into trouble in between backups, or you let your routine slide, or a friend has a crisis with their PC? That's where an emergency USB toolkit of portable apps comes in, giving you everything you need to fix the damage, and save the day.

When you install a program, not only are the files it needs to run saved on your hard drive, but it also makes its own changes to the rest of your system, such as adding entries to the Registry. Portable apps don't do this, so you can save them to a USB stick, and use them on any PC by double-clicking the program's EXE file. Here's our selection of the best ones for emergencies. **–CAT ELLIS**

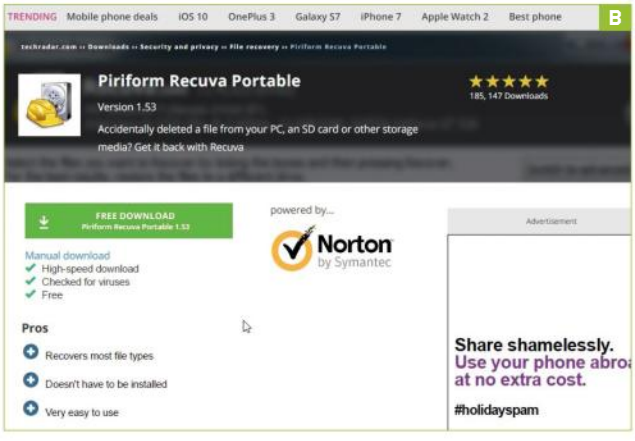


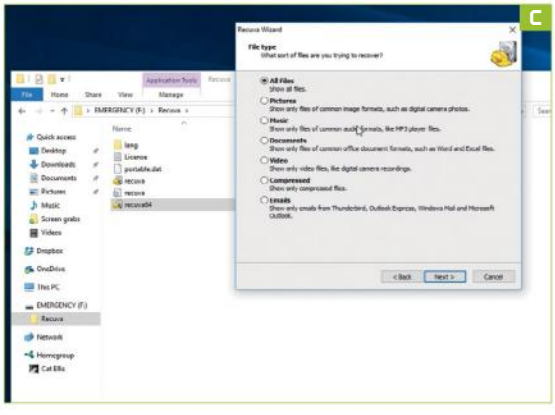
1 GET YOUR USB STICK READY

First, you need a USB memory stick—1GB is fine. Plug it into your computer, open Windows Explorer, then right-click your USB stick in the menu on the left. Select "Rename," and call it "Emergency." If you've used the memory stick before, you can wipe it by right-clicking it, and selecting "Format → Restore device defaults → OK" [**Image A**]. Make sure there isn't anything you want to keep on the stick first.

2 PREPARE FOR ACCIDENTS

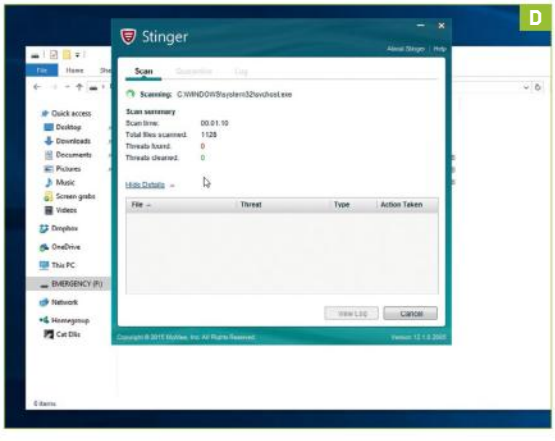
Now we need to start building our toolkit. A common disaster is accidentally deleting a file—whether it's from your hard drive, an SD card, or other storage. Piriform Recuva [**Image B**] can help you get it back, but installing this after you've lost files can result in them being overwritten, so it's far better to have it ready to run from your USB stick. Download it from www.piriform.com/recuva—using "Manual download" is easiest.

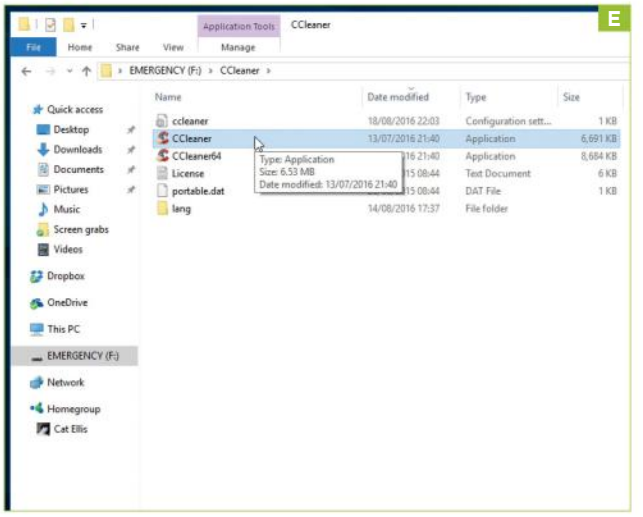




3 RECOVER DELETED FILES

Now click the downloaded ZIP file, and select "Extract → Extract all." Click "Browse," then select your USB stick. Right-click, and create a folder called "Recuva" (to make it easier to find in future). Open this folder, and click





"Select folder → Extract." Now, if you ever need to restore a deleted file, just plug in your USB stick, double-click Recuva.exe, and follow the instructions [**Image C**].

4 DOWNLOAD A VIRUS-ZAPPER

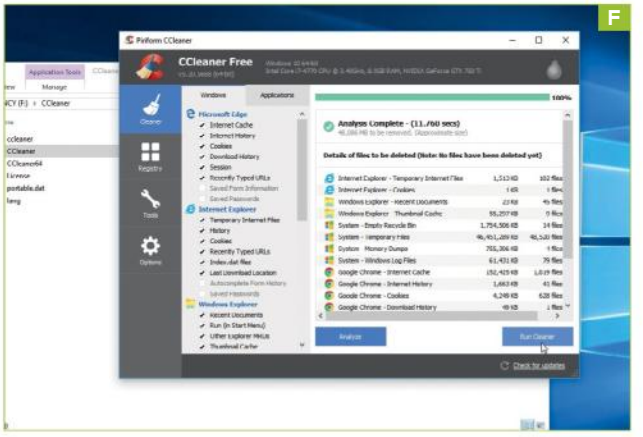
If you suspect your PC has been infected with a virus, McAfee Stinger can help stop it in its tracks. Download it from www.mcafee.com/uk/downloads/free-tools/stinger.aspx. This program doesn't come in a ZIP archive, so once it's downloaded to your PC, you can drag the EXE file straight to your USB stick using Windows Explorer. When you want to run it, just double-click the file, and click "Scan" [**Image D**].

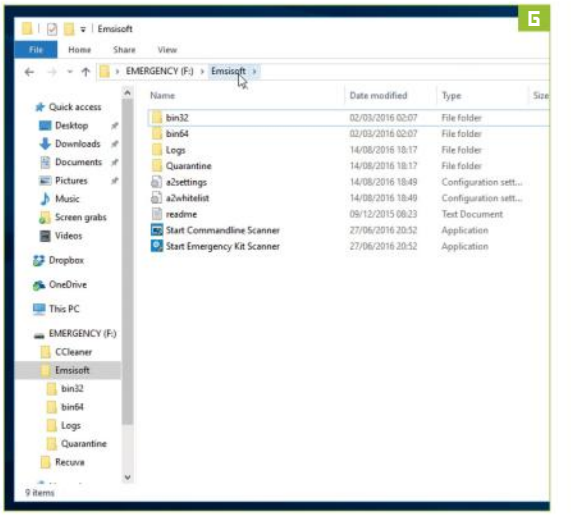
5 GET READY FOR A DEEP CLEAN

If your PC is running more slowly than it used to, or you're getting error messages about corrupted files, CCleaner can save the day. Download it from www.piriform.com/ccleaner/builds (it's the second link), then extract the downloaded file to your USB stick, just as you did for Recuva, saving it in a new folder called "CCleaner." Whenever you need to run it, just double-click the CCleaner.exe file [**Image E**].

6 SWEEP AWAY JUNK AND FIX ERRORS

To free up extra space and improve performance, click "Analyze," and CCleaner searches your hard drive for any unnecessary files. Once it's finished, look through the list, uncheck the boxes next to anything you want to keep, then click "Run Cleaner" [**Image F**]. To solve errors with the Windows Registry,





select "Registry" from the menu on the left, then select "Scan for issues → Fix selected issues."

7 GET SET TO BLAST MALWARE

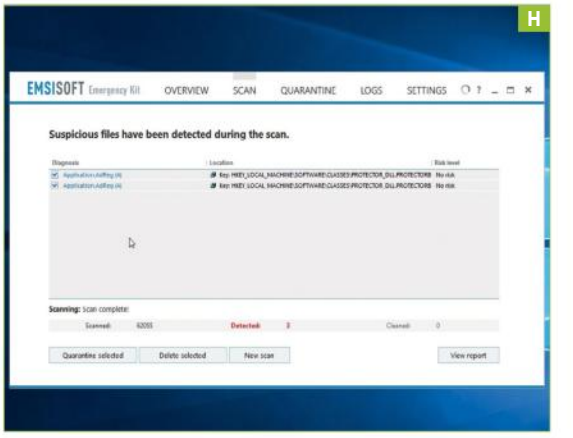
Emsisoft Emergency Kit, which is available from www.emsisoft.com/en/software/eek/, checks your computer for programs that aren't strictly viruses but are still malicious. Double-click the downloaded file, and it runs an installer, which automates the process of extracting the files from a ZIP archive. Select your USB stick as the destination, make a folder called "Emsisoft," and click "OK" [**Image G**].

8 READY FOR ANYTHING

Double-click "Start Emergency Kit Scanner," and let Emsisoft update itself. Now, whenever you think your PC has a malware infection (you notice unexpected changes to your web browser, for example), insert your USB stick, launch Emsisoft, click "Scan," and follow the instructions to deal with the issue [**Image H**]. Label the USB stick and keep it handy—you never know when you might need it.

9 ONE LAST POINT

You might have extra room on your USB stick once you've finished installing your emergency apps, but don't use it for regular file transfers—you don't want to risk losing it!



Manage Passwords With KeePassX

YOU'LL NEED THIS

KEEPASSX
Store your passwords securely on your machine with this free tool from www.keepassx.org.

Wherever you go these days, you need passwords. The number of websites that expect you to provide a username and password to access all their content is even greater than the number of sites providing helpful advice on good and bad practice for passwords. So what are we to do? You should already be using a secure operating system, but any system is only as secure as its users. Passwords are less effective once they are written on pieces of paper stuck to the sides of monitors, or saved in text files. The three questions we will try to answer here are: How should I choose my passwords, how can I check that my passwords really are secure enough, and how do I keep track of them without resorting to pieces of paper? –NEIL BOTHWICK

1 KEYS TO THE KINGDOM

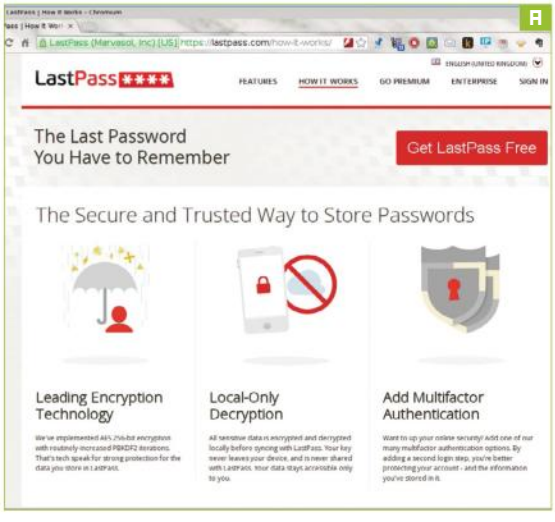
Ask people which they think is their most important password, and many will say that it is their login password (unless they use a password manager, in which case it may be that one). It isn't, though—your login password only gives access to your user account on your computer. The most dangerous password to have compromised is the one to your email account. Why? Think of all the websites you have to log into—how many of them have a "Click here if you forgot your password" link? These links generally send an email with a password reset URL to the email address you registered with them. If someone gets hold of your email credentials, they can use those details to discover your password for many websites, including ecommerce sites that may already hold payment details. It also means they can delete any responses and notifications about password resets, not to mention acknowledgement emails for any orders they may place using your account—so keep your email password safe, secure, and unique.

2 DANGEROUS REMINDERS

Even if your password is safe, email is not a secure medium; all data travels as plain text, so it's not a good idea to make a habit of email password reminders and resets. However, most people have more online identities and login names than they can remember passwords for, so how do you remember your passwords without breaking any of the golden rules about reusing the same password or using simple ones?

IF THE WORST HAPPENS

No, we're not talking about drunken mates discovering your Facebook password and making embarrassing status updates on your behalf. None of us will be here forever, so we should make sure there is a way for our families to access our online information and know about online billing when our time is up. When someone died recently, we were asked for help to extract a lot of important password-protected information from his smartphone, because no one else knew the password—as if his wife didn't have enough to worry about at the time. A copy of your password database on a USB stick, along with a note of the password (or details of your online password storage) in a safe place will make it possible for others to sort out your affairs after you're gone.

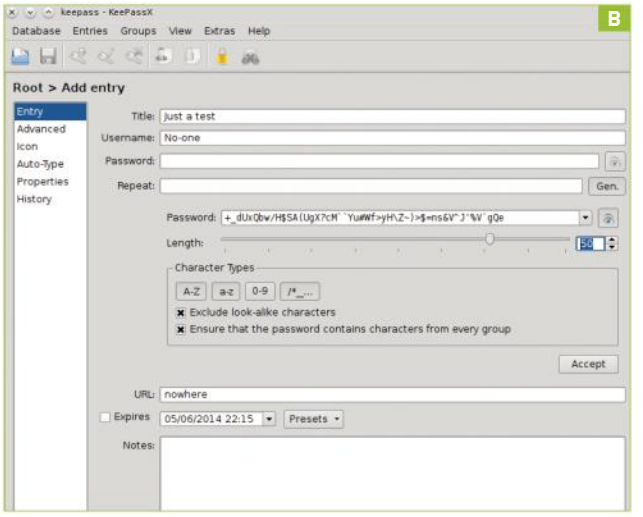


3 PASSWORD STORAGE

One solution is a password manager. Most web browsers have an option to save passwords, but these are neither universal nor portable. You could use a system such as LastPass (http://lastpass.com) [Image A], which stores your passwords and has extensions for most browsers to automatically complete forms. This means you only need to remember the master password, which you can then make more secure. However, such services may restrict you to web usage, and require you to entrust all of your passwords to a third party. Yes, they store the passwords encrypted, but they do so using their own encryption, not yours, so they are potentially susceptible to security breaches.

4 BUILD YOUR OWN

Another option is to keep your own password database, using a program such as KeePassX [Image B], which has versions that run on Windows, Mac OS, Linux, Android, and iOS. These all use the same storage format, enabling you to share your password database across any devices you own or have access to, especially if you keep the database itself in some sort of cloud storage, such as Dropbox, or even your own server, using ownCloud or similar.



5 CHOOSING PASSWORDS

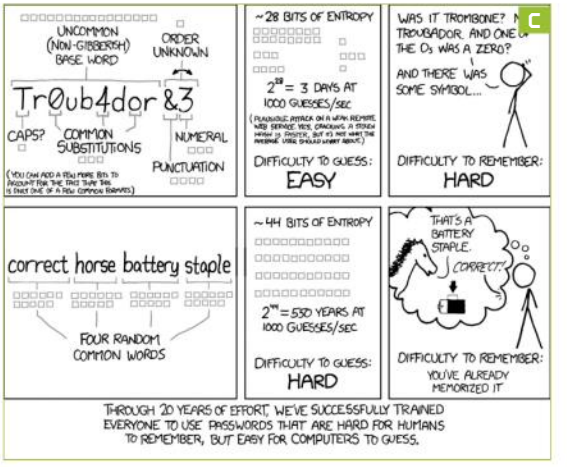
A password that is easy to crack is no use, but neither is one so convoluted that you don't stand a chance of remembering it yourself. If you use a password manager, many of them have an option to generate long, random, cryptic passwords, but you still need a password for the manager, and that has to be really secure. Any password not stored in a database has to be easy to remember but hard to guess.

6 COMPLICATED SIMPLICITY

There's a number of factors that affect the guessability of a password. Using so-called dictionary words—which also include proper nouns, place names, and common names—is a sure way to make your password easy to guess. Other important factors to consider are the number of characters used, and the number of possible choices for each character. Increasing either of these makes the password more secure, which is why it is commonly recommended to use mixed case, numbers, and even symbols.

7 STRONG PASSWORDS

However, these can make passwords far harder to remember, not to mention making them extremely tedious to type on a touchscreen keyboard. So how do you create a password that is long enough to be secure, isn't a dictionary word, and can be typed on a mobile device? One answer is the same way you create a less secure password, several times over. Ask someone to remember a 24-character password, and they will probably not even consider


C
UNCOMMON (NON-GIBBERISH) BASE WORD
ORDER UNKNOWN
Tr0ub4dor&3
CAPS?
COMMON SUBSTITUTIONS
NUMERAL
PUNCTUATION
~28 BITS OF ENTROPY
2^28 = 3 DAYS AT 1000 GUESSES/SEC
DIFFICULTY TO GUESS: EASY
WAS IT TROMBONE? NO, TROUBADOR. AND ONE O WAS A ZERO?
AND THERE WAS SOME SYMBOL...
DIFFICULTY TO REMEMBER: HARD
correct horse battery staple
FOUR RANDOM COMMON WORDS
~44 BITS OF ENTROPY
2^44 = 550 YEARS AT 1000 GUESSES/SEC
DIFFICULTY TO GUESS: HARD
THAT'S A BATTERY STAPLE.
CORRECT!
DIFFICULTY TO REMEMBER: YOU'VE ALREADY MEMORIZED IT
THROUGH 20 YEARS OF EFFORT, WE'VE SUCCESSFULLY TRAINED EVERYONE TO USE PASSWORDS THAT ARE HARD FOR HUMANS TO REMEMBER, BUT EASY FOR COMPUTERS TO GUESS.

it, but ask them to remember four six-letter passwords, and there will be no such reaction. All you then have to remember is the order of the four words run into one [Image C]. You can ring further changes, using numbers in place of some letters, *à la* leet speak, and using mixed case or deliberate misspellings. By doing so, you end up with a more secure password, as long as the four words you choose are unrelated in everyone's mind but your own. Most importantly, though, you can remember it, you do not need to write it down, or worry about forgetting it.

8 BETTER SECURITY FOR ALL

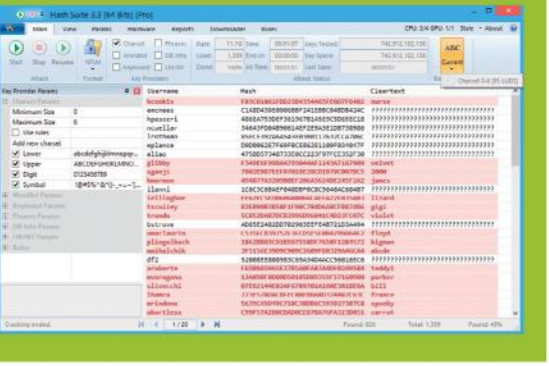
KeePassX uses an encrypted database to store URLs, login names, and passwords for your favorite sites. There are versions available for all desktop and mobile operating systems, so you can keep a single database everywhere. There is even a portable version of the Windows program that you can keep on a USB stick along with its database file.

KeePassX does more than simply store passwords; it can also type them into the browser for you. The default setting is to send the username, a tab, the password, and Enter, but you can change this for each site. Version 2 of KeePassX can be configured to send more than two items. Some sites, particularly banking sites, now require three pieces of information. Cryptic passwords can be generated automatically for each site, or you can pick your own and it will let you know how strong it is. The database is a single file, and an important one, so keep a copy in a safe place.

TEST YOUR (PASSWORD) STRENGTH!

How do you know whether or not you have a strong password? There's a number of websites that check password strength, and even give an indication of how long they would take to crack, such as https://howsecureismypassword.net. You don't want to give your real passwords to such sites, but you can use them to check the style of password you are using.

Another option is to use a downloadable tool, such as Hash Suite (http://hashsuite.openwall.net), to try to work out your passwords. This is a Windows utility developed by one of the contributors to the respected John the Ripper tool, which is only available for Linux and Mac OSes (www.openwall.com/john). These tools are primarily designed for system admins, but are also useful for anyone who is concerned about the strength of their passwords and system security.



Power Up Your Plex Media Server

YOU'LL NEED THIS

HARDWARE
Suitable low-end PC, NAS, or Raspberry Pi 2 or 3.

PLEX MEDIA SERVER
See www.plex.tv.

IF YOU'RE LOOKING FOR A MEDIA SERVER that doesn't just enable you to organize and play your media, but shows it off in the best possible way, you need Plex. It works across just about any device you own, and enables you to watch across multiple platforms, both at home and over the Internet, picking up where you left off watching on another device.

The biggest issue with Plex is choosing the server to run it on. A PC is an obvious choice, but it needs to be left on 24/7 for unlimited access. You're better off installing it on a dedicated low-power device, such as a high-end NAS, like QNAP's TS-251+, which boasts a quad-core Celeron CPU and hardware transcoding engine. But that's not necessarily affordable, so a cheaper NAS with app support (like the WD My Cloud [**Image A**]) or a Raspberry Pi 2 or 3 is capable of serving media.

The major trade-off is performance—you free up resources from your main PC, but your server is slower and visibly less responsive. It still does the job, though, and armed with the following tips, you'll squeeze that bit more performance from it to deliver a great media experience. **–NICK PEERS**

1 USE THE RIGHT FORMAT

The most effective way to improve performance is by reducing—or even eliminating—transcoding. Transcoding converts your media stream from its native format to one that's compatible with your media-playing device, so the more exotic and varied your media formats are, the more likely it is that Plex needs to transcode them.

›› Wherever possible, save your media in .mp4 file containers using the H.264 video and AAC or MP3 audio codecs—this is the closest to a universal format you can get, and most devices should be able to play it directly. Handbrake (www.handbrake.fr) can do this for you.

›› The critical elements here are the codecs—if you use a different file container (such as .mkv or .avi) with H.264 and AAC/MP3, Plex uses a process called Direct Stream to "remux" the file in a compatible container (typically .mp4) before streaming it. Although this requires extra processing power, remuxing is far less demanding than a full transcode.

2 ADD SUBTITLES

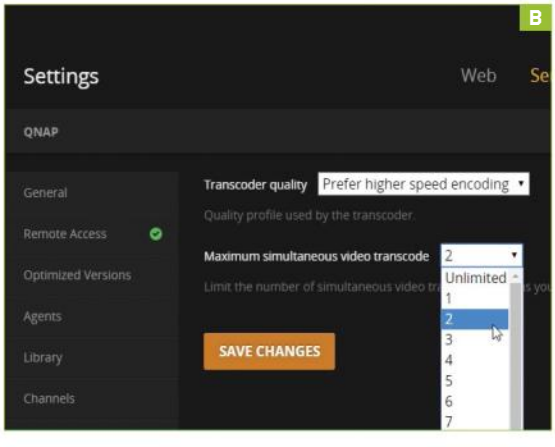
If you need subtitles, it's important to choose the right format if you use external files—otherwise Plex has to transcode the stream to accommodate them. Go to "Media Preparation → Subtitles" at https://support.plex.tv/hc/en-us for instructions. Here you'll discover which formats to choose to avoid transcoding (.srt and .vtt are two), along with a means of fetching subtitles on demand from the Internet using OpenSubtitles.org. Then browse to "Settings → Languages," check the "Automatically select" box, and set "Subtitle mode" to "Shown with foreign audio," and "Prefer subtitles in" to "English."

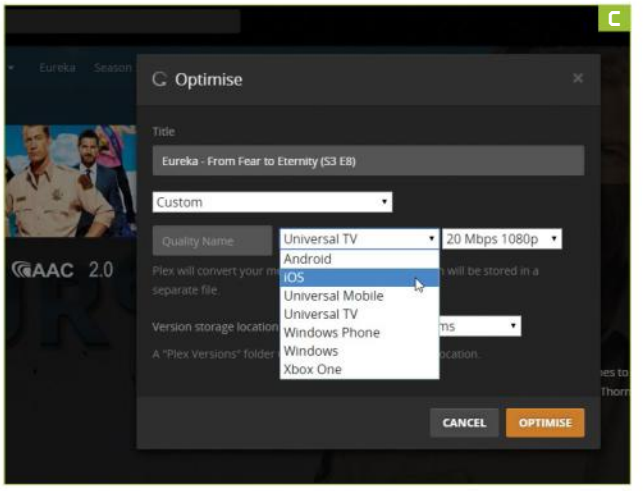
›› Subtitles are notorious for being out of sync—if your media player doesn't provide offset controls (typically in milliseconds), visit www.subsedit.com/simple to paste in your subtitles from a text editor, select an offset, and generate a new .srt file that syncs perfectly. Use VLC Media Player's "Tools → Track Synchronization" with the original .srt file to calculate the offset you need.

3 SPEED UP NETWORK CONNECTIONS

If you connect your server wirelessly to your network, you can improve its performance by taking it off your congested Wi-Fi network, and connecting it via Ethernet cable—either directly to your router, or indirectly via a switch or HomePlug network (500Mb/s is adequate, but 1,300Mb/s is best if your server frequently serves multiple streams).

›› Some NAS drives—including our beloved QNAP—offer dual Ethernet ports with support for Link Aggregation Control Protocol (802.3ad). Pair this with a suitable network





switch (such as TP-Link's affordable TL-SG2008 model), and you'll boost network throughput when serving multiple connections.

4 TRANSCODER SETTINGS

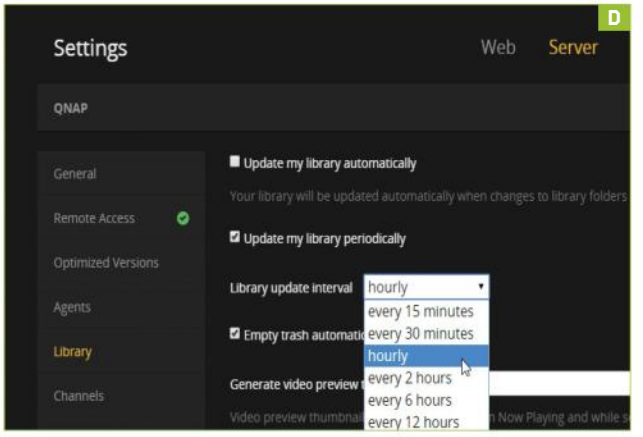
There's a noticeable lag when playing back media over the Internet—like it or not, this involves some transcoding, even with directly supported formats. To boost responsiveness at the expense of quality, log on to your server through your web browser: "192.168.x.y:32400/web," where "192.168.x.y" is the IP address of the device running your server. Choose "Settings → Transcoder," and set "Transcoder quality" to "Prefer higher speed encoding."

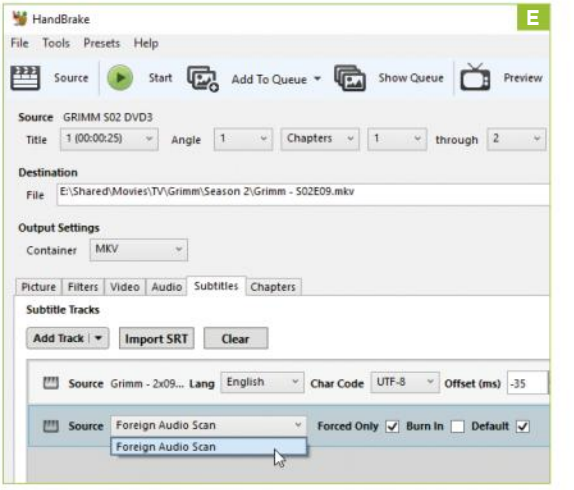
›› Plex is also set to transcode an unlimited number of streams—restrict this to just one or two via the "Maximum simultaneous video transcode" drop-down [**Image B**]. Note: This doesn't restrict Direct Play connections.

5 OPTIMIZE FOR TRANSPORT

Does Plex struggle to deliver a good stream to certain devices? You can use its Media Optimizer tool to make use of idle server time, by converting selected media files to a format that will stream using Direct Play, without buffering or dropping frames. The process produces a smaller, lower-quality copy of the file in question, which sits alongside the original, and improves streaming performance.

›› Don't optimize your entire library; instead, optimize on demand—maybe you're going away for a few days, and want access to three or four TV episodes or movies. To do this, log into the server in your web browser, then browse to the movie or episode in question. Click the "..." button in the left-hand pane, and choose





"Optimize." Pick a preset: Mobile, TV, Original, or Custom (this latter option lets you choose from more presets, or set your own frame rate and resolution). Leave the default storage location alone, and click "Optimize" [**Image C**].

6 TWEAK OPTIMIZATION SETTINGS

Media is optimized one file at a time, but you can build a queue. Check their progress via the "Conversion" tab. To manage optimized versions—allowing you to delete some or all of these converted files to reclaim drive space at a later date—go to "Settings → Optimized Versions."

›› Return to "Settings → Transcoder," and click "Show Advanced." At the bottom of the screen, you'll see the "Background transcoding x264 preset" setting—it's set to "Very fast" by default, but consider "Super fast," or even "Ultra fast," if the optimization process is taking too long, and you're not bothered by video quality.

7 RESTRICT LIBRARY UPDATES

Go to "Settings → Library" to manage how Plex updates your media libraries. By default, it monitors for new and changed content in your media folders, then updates accordingly. This isn't practical on lower-end media servers, such as the Raspberry Pi, so restrict the scan to no more than once an hour using the "Update my library periodically" option instead. Also consider setting "Generate video preview thumbnails" and "Generate chapter thumbnails" to "Never" to reclaim more system resources [**Image D**].

EMBED SUBTITLES

An alternative way to access subtitles is to embed them into your media using Handbrake. A full guide can be found under "Advanced Features" at https://handbrake.fr/docs/en/—but it's basically this: Load up your media, switch to the "Subtitles" tab, and either import your .srt file (you can set an offset if required), or click "Add Track" if ripping from DVD. Look for a "Foreign Audio Scan" option [**Image E**], which attempts to detect the foreign-language dialog track for you, then check both "Forced Only" and "Default" (or "Burn In" if you want the subtitles to be physically overlaid on the video track, which means they're visible even if subtitles are switched off). You'll never be bamboozled by Jabba the Hutt again.

Build Your Own Chromebook

YOU'LL NEED THIS

CHROMIUM OS
From http://arnoldthebat.co.uk.

LAPTOP
Any spare laptop should do.

THE FIRST QUESTION in your head is probably, "Why would I want to install Chrome OS, even on my old laptop, when there are perfectly adequate full-fat Linux distros to choose from?" Good question, and the answer is that not everyone wants a full-fat distro, nor can everyone use a full-fat distro. Part of the success of Chromebooks—and they are successful, with Chromebooks outselling Apple Macs in the United States in the first quarter of 2016—is their cut-down, lightweight Gentoo-based operating system. If you want to give someone easy, no-fuss access to Google services, it should be a tempting choice. –NEIL MOHR

1 CHROMIUM VS. CHROME

The good news is it's easy to install Chromium OS [Image A], the open-source project name for the official Google Chrome OS, which is only available through officially licensed Chromebook PCs. While it looks superficially different, with a blue theme running through it, Chromium OS taps into the same Google accounts and services, and offers the same advantages of automatically picking up your plugins and the rest, which are stored in the Google cloud.

2 CHOOSE YOUR HARDWARE

Built on Gentoo, Chromium OS is Linux-based, so has all the advantages of the Linux kernel—but keep in mind it was only rolled out in late 2009, so if you're planning on trying it on hardware older than that, you might not have as much luck. Having said that, we tried it on a standard Lenovo X200 laptop from 2008, and everything worked without a hitch. A general rule of thumb is: Any standard Intel hardware should work without trouble. One thing we do know is that non-Intel wireless adapters do cause issues; we'll go into this in more detail in a moment.

3 PICK A BUILD

A number of websites have maintained builds of Chromium OS. It's unlikely you'll want to build it yourself from source, so there are versions ready for VirtualBox, and for running and installing off a USB drive. We're using the build maintained at http://arnoldthebat.co.uk because it remains current at the time of writing. Another popular build can be downloaded from the Hexxeh website (http://chromeos.hexxeh.net). However, this doesn't appear to have been updated since April 2013, but it does still work.

4 TAKE CHROMIUM OS FOR A SPIN

You've got an array of options for trying Chromium OS. The easiest of them is to download an image, write it to a USB drive or SD card, and then boot this from your laptop or PC. There are live disc versions, too, but with writable media, you're able to save your settings and carry the operating system around with you, so you can use it on any machine.

5 STEP HEAD STYLE

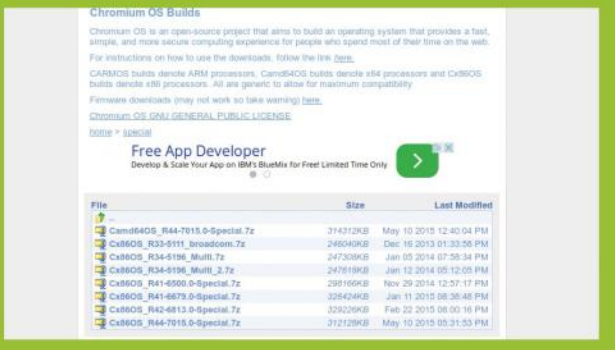
It's not advertised within the operating system, but there's a command that easily copies the OS partitions to an internal hard drive. This does wipe all existing data, but with cheap SSDs, it's not beyond the realms of possibility that you could buy a dedicated drive for this project. We did try dual-booting Chromium with Linux Mint, but it seems as though Chromium saw this as a repair state, and wouldn't play ball. Let us know if you have more luck, because it seems to be a relatively straightforward process to recreate the two ROOT-A and STATE partitions, then `dd` over these from the USB drive, and update Grub.

GOOGLE API KEYS

This part of the walkthrough isn't strictly necessary, and frankly, it's a pain in the butt to implement, because the keys are long, and if your font obfuscates "1," "L" and "I," then it's a pain to enter as well. However, if you want the Chromium Files app to work nicely with your external Google Drive account, this is the way to do it. You first need to get the keys from https://console.developers.google.com. Under "API," you need to select "Credentials," followed by "Create New Client ID for Installed Applications and Other Type," then select "Create New Key." Two entries with your API, ID, and Secret key will be listed. The second major step is adding the environmental variables to Chromium. In Vi, add the following three lines to the end of the configuration file, along with your new keys.

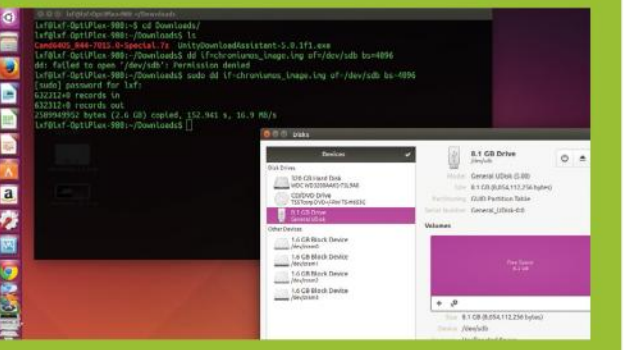
```
GOOGLE_API_KEY=
GOOGLE_DEFAULT_CLIENT_ID=
GOOGLE_DEFAULT_CLIENT_SECRET=
```

INSTALL AND UPDATE CHROMIUM OS



1. GRAB A BUILD

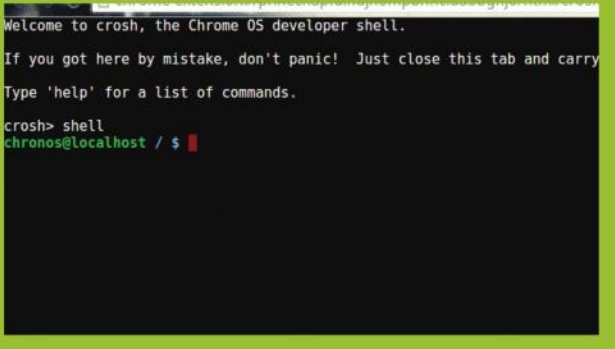
Grab the latest special build from http://bit.ly/2bh9TsJ—these builds retain all previous drivers, including Broadcom wireless, plus untested Realtek and Atheros wireless cards. Note the Cx86OS and Camd64OS builds for 32-bit and 64-bit support, so ensure you grab the correct version for your hardware to make the most of your memory.



2. BOOT MEDIA

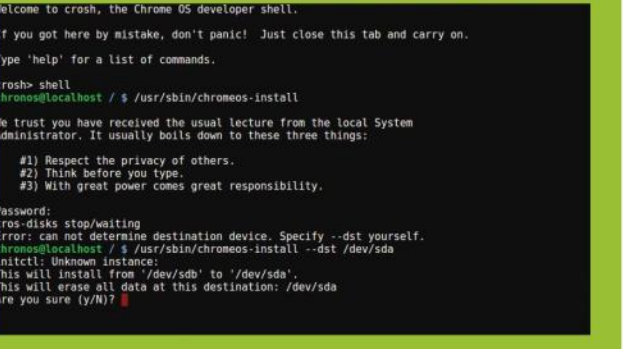
The 7ZIP file is about 1GB in size, and is a 2.4GB uncompressed IMG file. This needs to be `dd`'d to a suitably large USB device or SD card. You are able to run and use Chromium OS from this, but installing it on an internal SSD or HDD is the best option for speed, obviously:

```
$ sudo dd if=<ChromeOSname.img> of=/dev/sdbX bs=4M
```


Welcome to crosh, the Chrome OS developer shell.
If you got here by mistake, don't panic! Just close this tab and carry
Type 'help' for a list of commands.
crosh> shell
chronos@localhost / $

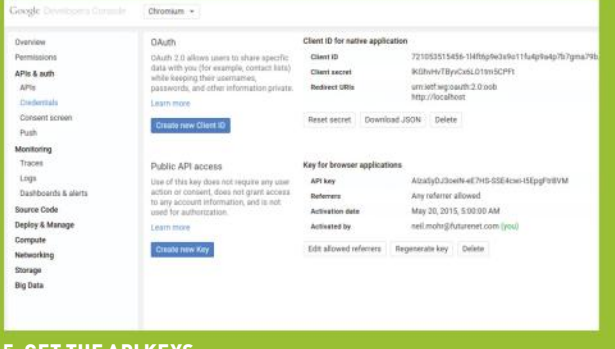
3. START CHROMIUM OS

Boot your laptop with the USB stick. You'll likely need to do the magic F12/Del/Special key to adjust the BIOS/UEFI boot priorities. You don't need to log into an account, as you can use the Guest account option. Press Ctrl-Alt-T to open the developer Chrome shell Crosh. Type `shell` to open a real Linux shell.


Welcome to crosh, the Chrome OS developer shell.
If you got here by mistake, don't panic! Just close this tab and carry on.
Type 'help' for a list of commands.
crosh> shell
chronos@localhost / $ /usr/sbin/chromeos-install
We trust you have received the usual lecture from the local System
Administrator. It usually boils down to these three things:
#1) Respect the privacy of others.
#2) Think before you type.
#3) With great power comes great responsibility.
Password:
cros-disks stop/waiting
Error: can not determine destination device. Specify --dst yourself.
chronos@localhost / $ /usr/sbin/chromeos-install --dst /dev/sda
initctl: Unknown instance:
This will install from '/dev/sdb' to '/dev/sda'.
This will erase all data at this destination: /dev/sda
Are you sure (y/N)?

4. INSTALL CHROMIUM OS

Warning! The next command wipes the entire internal hard drive—we didn't have much luck with dual-booting. If you're prompted for a password, use "password." At the shell, `$ /usr/sbin/chrome-install --dev /dev/sda` and away the install goes. Once complete, remove the USB stick and reboot.



5. GET THE API KEYS

Everything works, but parts of the OS can't access Google services without signed keys. Subscribe to the Google Code group at http://bit.ly/2d2QOqB, then access https://console.developers.google.com, and select "Create Project." Enable Drive API/SDK, Google Maps Geolocation API, and Google Now for Chrome API.

6. ADD THE KEYS

The keys are case-sensitive, so carefully enter them when asked for the password, which is "password." To do this, open Crosh, `$ shell`, `$ sudo su`, `$ mount -o remount,rw /`, `$ cd /etc`, `$ vi chome_dev.conf`. In Vi, enter the keys as detailed in the boxout (see left). Press Esc `wq!`, log out, log back in, and Chromium Files should now have access.

Control the Airflow Within Your Chassis

YOU'LL NEED THIS

A CASE AND FANS
All respectable cases have support for fan mounts internally.

INTERNAL AIRFLOW; let's cut the crap—it's one of the biggest dividers of opinion there is, second only to cake or pie. So, why is it so complex? What's a positive or negative pressure system? Static pressure? CFM? What's that? Well, that's what we're here to answer. Whether your woes lie with choosing which fans to use to cool your mighty AIO, or with the age-old argument between static pressure and high airflow fans, don't you worry—we've got your back!

Is internal airflow really that important? In a lot of ways, it's more vital than people realize; the more air you circulate, the better temperatures you'll have internally, and the more comfortable your overclocks will remain in turn. Also, you can wow everyone with your in-depth knowledge of fans. Come on—who doesn't love fan tips? **–ZAK STOREY**

1 FAN ORIENTATION

The first thing you need to identify when it comes to your fans is which way pulls air in, and which pushes it out. Most commonly, the side with the blades exposed is the intake, and the side with the guards will exhaust air around or out of your chassis.

2 STATIC PRESSURE VERSUS AIRFLOW

Identifying a static pressure optimized fan as opposed to an airflow fan is crucial. An easy way to tell them apart is the design and orientation of the fan blades. Fat and wide [**Image A**]? You're looking at a static pressure fan. Skinny and sleek? That's airflow optimized. Static pressure is designed to force air through dense or resistive areas, while airflow fans push larger quantities of air into a chassis at a lower pressure.

3 WHEN TO USE A STATIC PRESSURE FAN

We'll no doubt divide opinion here. Static pressure fans are absolutely fantastic for radiators, AIO coolers, and CPU heatsinks. Usually, those pesky air towers and radiators have a compact enough arrangement that a static pressure fan can easily take advantage of the higher pressure. However, this isn't always the case. For radiators, in particular, it can depend on the density of the fins within it, also known as FPI (fins per inch). In short, the higher the density, the higher the static pressure you'll need to push cool air through it. Take EKWB's XE 240mm radiator. It's a thick old girl—coming in at just under 2.4 inches in depth, it

features an FPI of just 16 [**Image B**]. However, if you take the PE variant, coming in at a meager 1.5 inches, you'll notice it has an FPI of 38. In this scenario, you would be far better off using a static pressure fan. However, the first radiator really wouldn't see any gains from using one, because the density is just too low.

4 WHEN TO USE AN AIRFLOW FAN

This is a little easier to answer now we've clarified the radiator conundrum. In short, if you've got absolutely no resistance, unless you're trying to thematically match a build with all the same fans, you should always choose an airflow optimized fan. It's not as difficult as it sounds—most companies offer both static pressure optimized and a standard airflow variant of the same fan design; Corsair's AF120 and SP120 series, for example. Of course, if your radiator has less than 18 FPI, you'll actually save yourself a few bucks by grabbing that airflow fan instead of the SP variant, because you won't see any performance benefits with an SP fan.

5 WHAT'S ALL THIS ABOUT RPM?

RPM, or revolutions per minute, applies here exactly as it would in a combustion engine. The higher the revolutions, the higher the performance, but that comes at a price. Noctua's NF-F12 IPPC fans are a good example. They come in two variants (three if you include the IP67 version): a 3,000rpm version, and a 2,000rpm version. Now, the 3,000 variant pushes 109.8 CFM (cubic feet per minute)

C

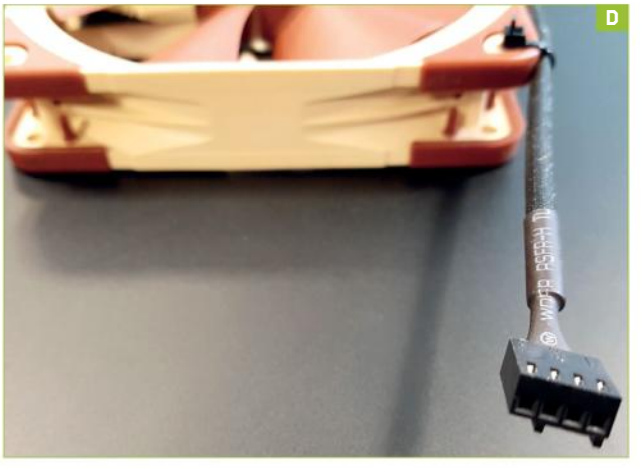
for airflow, and has a phenomenal static pressure of 7.63mm H_2O. However, at full whack, you also get a very noisy 43.5dB(A), which is bad. Compare that with the 2,000rpm variant, and you're down to 71.7 CFM on airflow, and a static pressure rating of 3.94mm H_2O. The advantage? You'll be greeted by 29.7dB(A) instead, which is around the same as a stock Corsair fan found in the H100i.

6 HOW CAN YOU REDUCE NOISE LEVELS?

Short of buying slower fans (1,500rpm or below), you can use low-noise adapters to reduce the voltage powering the fan, or use PWM variants instead, so you can control the fan speeds with pinprick precision through fan control software on your desktop. You could also install fans with rubber grommets [Image C], as opposed to the traditional fan screw. Outside of fans, you could opt for a noise-optimized case—one that uses sound-dampening material, such as Fractal's Define R5. Although the side panels will inherently be heavier, due to the noise-dampening fabric attached to the interior panels, it will deaden any excessive vibrations dramatically. Failing that, you could opt to use a fan controller, such as Phantek's PWM fan hub. These work similarly to a low-noise adapter, and most enable you to plug both PWM and 3-pin fan headers directly into them, which are then controlled by a single header, or software on the motherboard itself.

7 WHAT DO ALL THOSE NUMBERS MEAN?

To get a good idea of what these figures represent, your best bet is to compare several different fans on your favorite etailer's website. But for a quick roundup, static pressure is often measured in mm H_2O (2.2 is the average), higher equals better. Airflow is measured in CFM (70–80 is the average), higher is still better. Noise levels are measured in dB(A), 16 being super-quiet, 30 being your average CPU cooler fan at full load, 40 being a localized


D

E

earthquake within your chassis (OK, we jest here, but you get the point).

8 PULSE WIDTH MODULATION (PWM)

PWM fans account for about 30 percent of the total fans out there today. In short, instead of utilizing 12V, 7V, or 5V to power the fans, the additional pin [Image D] allows the motherboard to fluctuate the amount of voltage powering the fan. This way, it can control the fan's speed with incredible accuracy.

9 WHAT'S NEGATIVE AND POSITIVE PRESSURE?

These phrases refer to how you have your case set up. It sounds ridiculous, but once you introduce fans to a system, you actually create a pressure system inside the closed chassis. There are three different types of pressure system: a balanced system, where there's just as much air going in as going out (two intakes, two exhausts); a negative pressure system, where more air is being exhausted than is being brought into the chassis (one intake, three exhausts); and a positive pressure system, where more air is being brought into the chassis than exhausted (three intakes, one exhaust). In reality, they are all equally effective at cooling, and you'll only find very minor differences between the three. After all, exhausting hot air out of your chassis helps keep your motherboard on ice and your overclocks steady, and replacing that hot air with cold air through an intake helps as well. Ultimately, it's all about air circulation, far more than whether you run a positive, negative, or balanced system.

10 BALANCE IS KEY, THEN?

Well, no—it's actually more about dust than anything else. In today's world, cases are littered with dust filters: intakes designed to reduce the amount of dust entering your system. After all, dust is the biggest hardware killer of them all, and for an aesthetic build, it looks awful as well. But even with all of those filters, you're still going to have holes and areas that aren't filtered (rear exhaust slots, PCIe slots, and other gaps in the case's construction). In a negative system, thanks to thermodynamics, cool air is pulled in through all of these unfiltered areas, in turn bringing dust into the system. However, in a positive system [Image E], air is actually exhausted or pushed out of these gaps and unfiltered areas, pushing the dust out of your case as well. It's not going to keep the dust out indefinitely, but it'll certainly help, and it means your system will require a lot less maintenance overall.

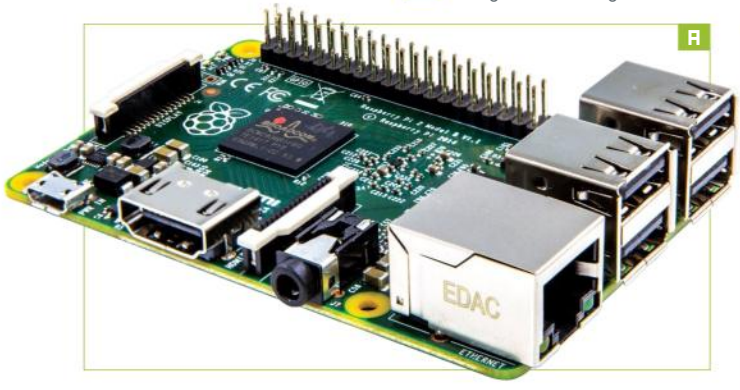
Create a Clever Wall Calendar

YOU'LL NEED THIS

RASPBERRY Pi
The brilliant mini-computer costs under $45. See www.raspberrypi.org.

ONE STAPLE IN FUTURISTIC FILMS is that everyone has a handy panel on the wall showing their appointments for the day. While we have calendars on our smartphones and tablets, now, thanks to the Raspberry Pi, it's possible to have an economic wall-mounted calendar in your home or office.

Given that we have just admitted that we could, for instance, use a calendar app on our phones instead, is this just a novelty, or are there any advantages to doing this? Well, mounting your calendar on a wall is certainly more aesthetically pleasing than many smartphones, but the main advantage is that it enables you to share a calendar with others, by putting it in a public place, such as your living room. Your family can see your own appointments, and you can make sure you schedule your commitments around theirs. In the workplace, you can use calendar views, such as Agenda in Google Calendars, to organize meetings and assign tasks to colleagues. **–NATE DRAKE**



1 CRAFTING YOUR CALENDAR

For this project, you need a Raspberry Pi with Internet access [Image A]. In the interests of saving on cabling and space, it's best to use the Raspberry Pi 3, which has integrated Wi-Fi.

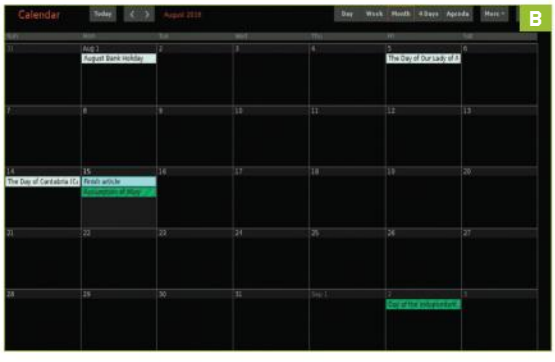
›› You also need to choose a monitor. One excellent option is the Official Raspberry Pi Touchscreen Display (see "Choosing a Monitor," opposite) but any compatible monitor will do. This isn't a DIY tutorial, so please only attempt to mount the Raspberry Pi and display if you are comfortable with using a drill and installing brackets. If the display comes with a stand, there's no reason it can't be placed on a desk or table.

›› This is also a good time to start measuring cable lengths, so you can be sure both the monitor and the Pi will have power wherever they're mounted.

›› Once your equipment is in order, you need to consider the type of calendar you wish to use. If you and your family or colleagues already have a calendar you share, you can start following the tutorial right away.

›› If that's not the case, you may wish to create a single calendar for this purpose. If you're using Google Calendars, you can follow the steps at https://support.google.com/calendar/answer/37095?hl=en to do this. For Mac users, visit https://support.apple.com/kb/PH2674?locale=en_US to create a new iCloud Calendar. Outlook users can also create a calendar by visiting http://calendar.live.com.

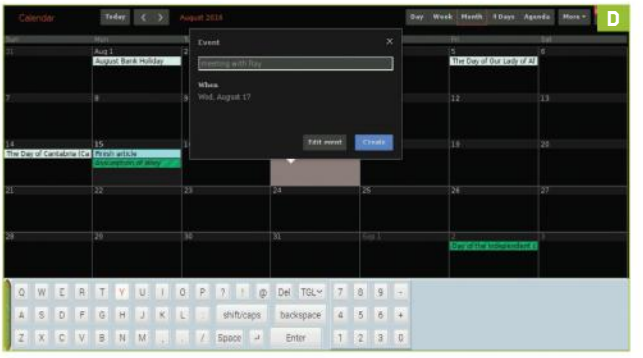
›› It's not particularly important which calendar service you use, provided it can be displayed in Mozilla Firefox, which we're using for this project. Try to give the calendar a distinctive name, such as "Smith Family Calendar," so everyone using it knows it's distinct from their personal calendar.



2 IMPORTING CALENDARS

If you do have an existing calendar, you may wish to import your personal appointments, birthdays, and so on into the new one. It may not be necessary, because providers such as Google and iCloud allow multiple calendars. Events are color-coded to show which calendar they belong to [Image B].

›› However, if one of the people using your new calendar previously used a different platform—for example, you have decided that you will all use a Google Calendar, but



one person has been using an iCloud one on their iPhone—you need to import it.

» To import events from an iCloud Calendar into Google, first export them into an ICS file by following the steps at https://support.apple.com/kb/PH11524?locale=en_US. Then import the file by following Step 2 at https://support.google.com/calendar/answer/37118?hl=en.

» To export a Microsoft Outlook Calendar to Google Calendar, follow the steps at http://bit.ly/2cl17lN.

3 CUSTOMIZATION

Once you have a single, shared calendar, take some time to set it to a format with which you're comfortable. Most providers have the option of a daily, weekly, or monthly view.

» Next, feel free to fine-tune the appearance. You can make changes to the iCloud Calendar—for example, to change the viewable time period—by following the instructions at https://support.apple.com/kb/PH2678?locale=en_US.

» Google Calendar's default look and feel is rather spartan. If you would like to experiment with different themes, there's a number available from https://userstyles.org/styles/browse?search_terms=google+calendar. However, you need the Stylish Firefox extension in order to install them, so visit https://addons.mozilla.org/en-US/firefox/addon/stylish/?src=ss, then click "Add to Firefox" to install this.

4 FULL-SCREEN AHEAD

Because you'll be using a much smaller screen than you're used to, space will be at a premium, so consider installing the Real Kiosk (r-kiosk) add-on for Mozilla Firefox. Real Kiosk does what it says on the tin: It's designed to turn your browser into the equivalent of an Internet kiosk. This means the menus, toolbars, and even the right-click function are disabled. The chief advantage of this is that Firefox always opens in full-screen mode, making your calendar much easier to see. This also makes sure your device can only be used as a calendar, because people trying to view other websites are bounced back.

» If you do need to close down Firefox for any reason, you can do this by connecting a keyboard, holding down the Alt key, then pressing F4.

5 EDITING YOUR CALENDARS

Reading this project so far, it would seem that viewing the calendar in the web browser is a passive experience. However, if you have a central calendar on your wall, wouldn't it be ideal to let people add and edit appointments as well?

» If you are using the official Raspberry Pi Touchscreen Display [**Image C**], tapping anywhere with your finger simulates moving the mouse and left-clicking in that place. You can use this to edit the time of events, and even create new ones.

» Problems may arise when you want to edit the text of events or create names for new ones. Naturally, you could connect a small wireless keyboard, and leave it near the wall-mounted calendar in case data needs to be entered.

» A much less clumsy solution, however, would be to have the keyboard built into the browser itself. The Mozilla Firefox extension VKeyBoard [**Image D**] is designed for kiosk browsers, and pops up when clicked to allow users to enter text.

» Simply visit https://addons.mozilla.org/en-US/firefox/addon/vkeyboard/?src=search inside the browser, and click "Add to Firefox" to install. If you have already installed the r-kiosk add-on, and can't change your web page, restart Firefox in safe mode, as outlined above.

6 SHARING THE DATES

If you want to use any device besides the Pi to add or change appointments in Google Calendar, you either need to sign into your Google or iCloud account on that device, or share your calendar with others.

» To share your Google Calendar, follow the steps at https://support.google.com/calendar/answer/37082?hl=en. You can send a link to only certain email addresses,

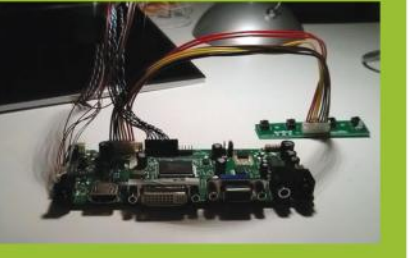
CHOOSING A MONITOR

There's no shortage of suitable small monitors to connect to your Raspberry Pi. If you feel comfortable with a small amount of wiring, the Official Raspberry Pi Seven-Inch Touchscreen Display is the ideal size to display a calendar, as well as having a handy slot at the back to place your Pi. The screen, along with assembly instructions, is available from the Adafruit website for $80 (www.adafruit.com).

If you don't like messy wires all over the place, Amazon sells a short micro-USB power cable for about $3, to allow the Raspberry Pi to draw power from the monitor's USB port.

The Touchscreen Display has the added advantage of enabling you to scroll through appointments with a click of a finger. If this isn't important, or the display is out of your budget, Amazon and eBay also sell Pi-compatible displays. As the Pi has an HDMI port, any HDMI-compatible monitor will do, but some come with a driver board to allow you to connect it to the Pi's own DSI port.

If you are very comfortable with electronics, and want to save money, find



a broken-down laptop with a working LCD. If you can remove the screen safely and buy a compatible controller board online, it can be made to work with the Raspberry Pi. Visit www.instructables.com/id/Old-laptop-screen-into-Monitor/?ALLSTEPS for some tips.

or make the calendar viewable to anyone with the link. You can do the same for iCloud Calendars by following the steps at https://support.apple.com/kb/ph2690?locale=en_US.

» If you use Outlook 2010, it's also possible to publish a calendar to Outlook.com by visiting https://support.office.com/en-ie/article/Share-an-Outlook-calendar-with-other-people-cafb9303-1b1e-40d3-839d-b6abac03a5e8#__toc300732657, and following the section entitled "Share a Calendar by Publishing it Online."

» Once your calendar has been shared online, people who wish to edit it need to access it from their own devices. For anyone with a computer, this is a simple matter of visiting the link, as you would on the Pi, by using their browser.

» It's also possible to view and edit the calendar on smartphones. If the shared calendar is with Google, Android users can access it from their own calendar app, even if they have a different Google account, by following the instructions at https://support.google.com/calendar/answer/37100?co=GENIE.Platform%3DDesktop&hl=en. There is an official Outlook app for Android, which allows for easy viewing and editing of Outlook calendars. Sadly, iCloud Calendars aren't so easy, but there's a number of third-party apps, such as SmoothSync, in the Google Play store, which enable you to synchronize between calendars. If you are an iPhone user, you're in luck. There's an official Google Calendar app in the iTunes Store, with which you can sign in and view your calendars. There is also an official Microsoft Outlook Email and Calendar app, which can be used to view and edit Outlook Calendars.

7 CALENDAR CONUNDRUMS

If you create or change an appointment, and it doesn't appear right away on everyone's device, wait for 5–10 minutes before attempting troubleshooting, to let it percolate through. If the changes are visible on the wall calendar—that is, on the website—the issue is most likely to do with the device, not the Raspberry Pi.

» The software and add-ons used to view the calendar are very easy to install, so the most problematic part of this project is likely to be when it comes to adding the monitor, and fixing it to your wall [**Image E**].

» You can make life much easier for yourself by buying a monitor specifically designed for the Raspberry Pi, so you have somewhere to put the computer itself.

» If the place you want to install the wall calendar is hard to reach, you may be able to buy a longer micro-USB cable, but bear in mind that the voltage drops as cable length grows. Consider using shorter cables and/or a powered USB hub.

» If the Raspberry Pi crashes for any reason, Firefox tries to restore all open web pages once it reboots, which may mean you have to plug in a mouse or keyboard to close down any extra tabs.

» You can reduce the chance of this happening by starting Firefox in safe mode, and then entering "about:config" in the address bar. Press Return to be taken to the settings screen for Firefox.

» Once you're there, simply scroll down to the setting marked "Browser.sessionstore.resume_from_crash," and double-click to change from "True" to "False."

» If you are using Google Calendars, anyone who scrolls to the top of the screen can switch from your calendar to your other Google Apps, such as Gmail. They can also use the search bar to view documents stored in your Google Drive.

» If this concerns you, consider setting up a dedicated Google account, just for the calendar. You can still access and edit the calendar from your own account.

CALENDAR TWEAKS & TIPS

When the calendar is on your wall, the cursor can look untidy, especially when using a touchscreen. A handy app called Unclutter can hide the cursor except when it's being moved or you're touching the screen. Open Terminal on your Pi (or connect via SSH), and run the command `sudo apt-get install unclutter`.

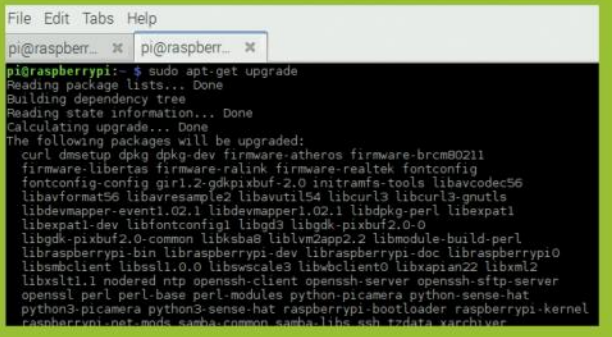
In case the Pi crashes, and you're forced to reboot, it's best to have Firefox programmed to open automatically, saving you the trouble of reconnecting a keyboard and mouse. Open Terminal on your Pi (or connect via SSH), and run the command `sudo nano /etc/xdg/lxsession/LXDE-pi/autostart`. Scroll to the bottom of the window and add the line `@firefox-esr`. Press Ctrl-X, then Y, then Return to save your changes.

Finally, to make sure the display doesn't sleep after a few minutes, open Terminal or connect via SSH once again, and run the command `sudo nano /etc/lightdm/lightdm.conf`. Scroll down to where it says `#xserver-command=X` and remove the hash at the start of the line. Next, put a space after the letter `X` and type `-s 0 -dpms`. Press Ctrl-X, then Y, then Return to save your changes, then reboot your Raspberry Pi.

If you are using Google Calendars, click the arrow

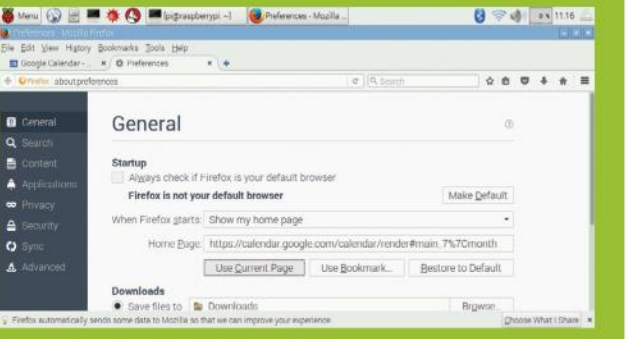
beside "Other Calendars," then "Browse Interesting Calendars," to see a list of calendars to which you can subscribe—for example, Holidays in Ireland. Click "Subscribe" to have them appear on your own calendar.

SET UP YOUR WALL CALENDAR


File Edit Tabs Help
pi@raspberr... pi@raspberr...
pi@raspberrypi:~ $ sudo apt-get upgrade
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
The following packages will be upgraded:
curl dmsetup dpkg dpkg-dev firmware-atheros firmware-brcm80211
firmware-libertas firmware-ralink firmware-realtek fontconfig
fontconfig-config gir1.2-gdkpixbuf-2.0 initramfs-tools libavcodec56
libavformat56 libavresample2 libavutil54 libcurl3 libcurl3-gnutls
libdevmapper-event1.02.1 libdevmapper1.02.1 libdpkg-perl libexpat1
libexpat1-dev libfontconfig1 libgd3 libgdk-pixbuf2.0-0
libgdk-pixbuf2.0-common libksba8 liblvm2app2.2 libmodule-build-perl
libraspberrypi-bin libraspberrypi-dev libraspberrypi-doc libraspberrypi0
libsmbclient libssl1.0.0 libswscale3 libwbclient0 libxapian22 libxml2
libxslt1.1 nodered ntp openssh-client openssh-server openssh-sftp-server
openssl perl perl-base perl-modules python-picamera python-sense-hat
python3-picamera python3-sense-hat raspberrypi-bootloader raspberrypi-kernel

1. UPDATE RASPBIAN AND INSTALL FIREFOX

Before you can physically transform your Raspberry Pi into a wall calendar, you need to connect the device to the Internet, and open the Terminal app. Run `sudo apt-get update` and then `sudo apt-get upgrade` to bring your RPi up to date. Next, enter `sudo apt-get install iceweasel` to install Firefox Extended Support Release on to your mini computer.

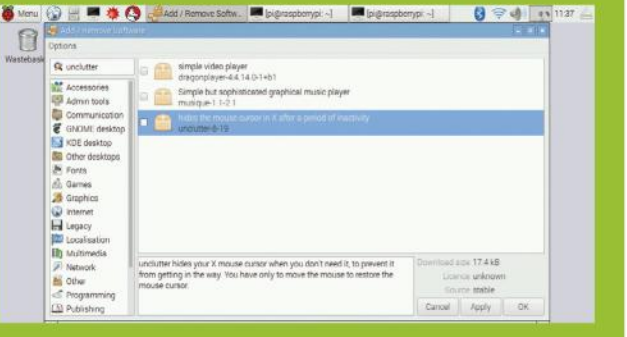


2. SET FIREFOX PREFERENCES

Go to "Menu → Internet → Firefox ESR" to open Firefox. Visit your calendar address—http://calendar.google.com, for example—and sign in if necessary. If Firefox prompts you to remember your preferences, say "Yes." Once you can see your calendar, go to "Edit → Preferences," and click the "Set to Current Page" button to make sure Firefox always displays the calendar.

3. SET FIREFOX FOR FULL-SCREEN

This step is optional but recommended. Visit https://addons.mozilla.org/en-US/firefox/addon/r-kiosk/ to install the Real Kiosk add-on—this disables menus and toolbars. Firefox needs to restart for it to work. Remember, you can still close the window by connecting a keyboard to the Raspberry Pi, and pressing Alt-F4.



4. PERFORM TWEAKS

Make sure the calendar is in the view you want—for example, Monthly. Next, follow the steps in the "Calendar Tweaks and Tips" box (opposite) to hide the mouse when not in use, disable the RPi's sleep function, and make Firefox start every time you switch on the machine, if you wish. Restart the RPi to ensure your changes have taken effect.

5. CONNECT IT UP

The specific steps to connect your monitor vary from device to device. If you are using the official Raspberry Pi Touchscreen Display, assembly instructions are available from http://thepihut.com/blogs/raspberry-pi-tutorials/45295044-raspberry-pi-7-touch-screen-assembly-guide.

6. FINISHING TOUCHES

Once you've connected your Raspberry Pi up to a screen, you'll want to position it somewhere that everyone can access. If it's in your home, you'll probably also want to make it look as good as possible. You can let your imagination run wild here—take a look online to see what other people have achieved.

Make Some Noise with Sonic Pi

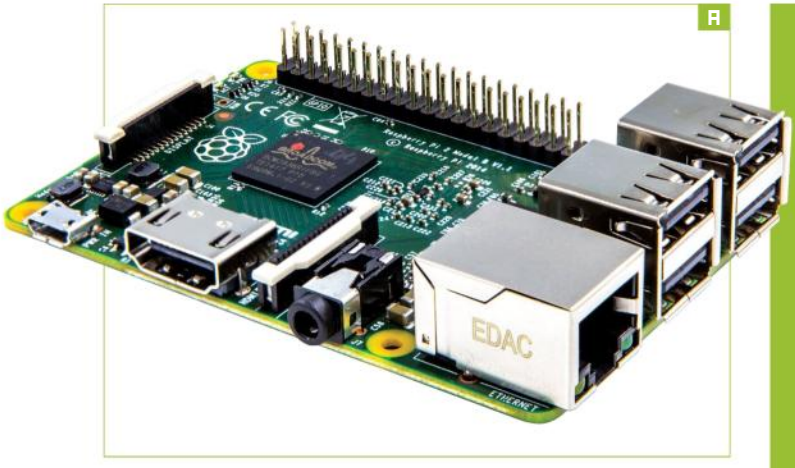
YOU'LL NEED THIS

RASPBERRY PI
Any model.

RASPBIAN
Available from www.raspberrypi.org/downloads.

THIS MONTH, we're serving up a selection of "phat beats" using nothing more than a Raspberry Pi [**Image A**] and Raspbian (which comes with Sonic Pi preinstalled). This is the personal project of Dr Sam Aaron, and the goal of Sonic Pi is to introduce creativity into programming via music, and reduce the friction that's encountered by children learning to code – for example, the alignment and indentation of code, and syntax errors.

Sonic Pi uses the Ruby programming language created in the mid 1990s by Yukihiro "Matz" Matsumoto, which was an easy-to-learn and syntax-friendly alternative to the languages of that time. Sonic Pi refines the Ruby language to provide a number of easy-to-use functions that enable learning. In this tutorial, we're teaching the basics of Sonic Pi, then consolidating that knowledge with a piece of music. **–LES POUNDER**



1 INTRODUCING SONIC PI

Sonic Pi comes preinstalled with Raspbian, but if you have an older installation, it's possible that your version of Sonic Pi is quite old. It's well worth updating the software installed on your Pi by opening a terminal, and typing the following:

```
$ sudo apt-get update
$ sudo apt-get upgrade
```

» If you are prompted to confirm installation, please do so. With Sonic Pi installed, you can find the application in the "Programming" menu. Open the interface, and you'll see that it is split into three vertically tiled panes. The top pane [**Image B**] contains a row of buttons that are used to control the playback of your composition, save the composition to a file, and also record the audio to a WAV file. Further buttons are used to reduce the text size of your code, align and indent code automatically, and access the Help/Preferences system. The center pane [**Image C**] contains the area in which code is written, which is split into a series of workspaces, enabling you to write multiple compositions or test logic in a spare workspace [**Image D**]. To the right of the code space is the Preferences area [**Image E**], where configuration changes can be made at the bottom. We also have the Help area [**Image F**], which contains extensive help documentation and example compositions.

2 YOUR FIRST NOTES

Let's start our musical adventure by playing a note. In the coding pane, type `play 60`. Now click "Run" on the top pane. You should hear the note play briefly. What does 60 mean? Well, it refers to the MIDI (Musical Instrument Digital Interface) numbering scheme, which is used in professional music production to cover the protocol by which data is sent to and from computers and digital instruments, but it also covers the connection made between the devices. The "60" note refers to a "c4" note, but we can just use the name of the note instead, so you could type `play :c4`.

» If we wanted to play a series of notes, we could type out something like:

```
play :c4
sleep 1
play :g4
sleep 1
play :d4
sleep 1
```

This is a correct but rather long-winded approach. Instead, Sonic Pi enables you to play patterns of notes in the same manner with:

```
play_pattern [ :c4, :g4, :d4 ]
```

» Perhaps the notes are a little too slow for you? Well, Sonic Pi has you covered. To speed up the playback of a composition, we can set the beats per minute (BPM) for playing that pattern of notes faster:

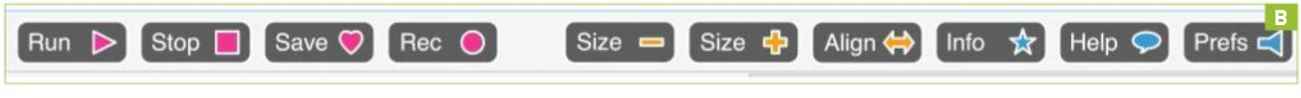
```
use_bpm 240
play_pattern [ :c4, :g4, :d4 ]
```

3 USING SYNTHS

OK, we can play a series of notes, but right now, it's not very exciting, so let's introduce another feature of Sonic Pi: synths.

» Synths enable a note to be played with many different instruments, similar to electronic keyboards and other digital instruments. So let's alter our code to use a synth:

```
use_synth :dsaw
play :c4
```



» Click "Run" to hear the difference. Now that we can play a note with a synth, let's put it into a loop to repeat playback. Sonic Pi can create an infinite loop using the `loop do...end` construct. Any code inside the loop repeats forever. To ensure that your code is properly indented, click the "Align" button in the top pane to automatically align the code:

```
loop do
  use_synth :dsaw
  play :c4
  sleep 1
end
```

» Click "Run" and you hear the c4 note played once per second until "Stop" is clicked. But what if we want to iterate a loop for a set number of times? Ruby has an easy way to do this:

```
2.times do
  use_synth :dsaw
  play :c4
  sleep 1
end
```

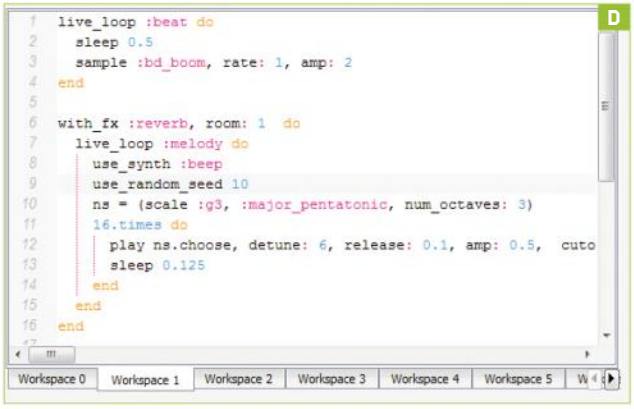
4 PLAYING LIVE

Another kind of loop is a live_loop. This is an infinite loop to be used when live coding a performance. Changes made to code inside a live_loop don't instantly take effect—rather, they require the user to click "Run" to instigate the changes the next time the loop is run. Live_loops enable the user to create concurrency where multiple segments of code are working together to form the backdrop of our music. The syntax for a live_loop is similar to a standard loop, but requires a name to be given

LIVE CODING!

Dr Sam Aaron is a bright and bubbly individual, who knows his craft well and loves to show others, so it's no surprise that he's a big advocate of live coding, the practice of coding in front of a live audience. Sam was part of the band Meta-ex (http://meta-ex.com), along with Jonathan Graham. Together they merged coding with musical instruments to create unique performances, where the audience could see the code transform to match the tone and pace of the music.

At a recent OpenTech event, we saw open data, in the form of natural disaster data, being used to shape the notes used in a rather eclectic piece of music. The piece, co-produced by Leah Borromeo and Jamie Perera, used data sonification. However, this wasn't a real-time project, which opens the door for Sonic Pi to be used with open data in a live coding exhibition. Data from a number of sources, such as newspapers, weather forecasts, and governments can be "mashed" into a live coding musical composition that can illustrate the subject of the data being used.



to the loop. So, let's create a loop named "beat," which incorporates the `play_pattern` function that we learned earlier. Then click "Run" to play.

```
live_loop :beat do
  use_synth :dsaw
  play_pattern [ :c4, :g4, :d4 ]
  sleep 1
end
```

» Change the c4 note for an f4 note, and click "Run"—you should hear the note change in pitch accordingly. We can also play a pattern backward, using Ruby's handy `.reverse` function, like so:

```
live_loop :beat do
  use_synth :dsaw
  play_pattern [ :c4, :g4, :d4 ].reverse
  sleep 1
end
```

5 RANDOMIZE THINGS

As well as playing notes forward and backward, we can also play random notes using two functions:

```
play rrand(50, 100)
play rrand_i(50, 100)
```

» The first `rrand` can play any note between 50 and 100, including any floating point MIDI values, but the second `rrand_i` can only play integer-based MIDI values between 50 and 100.

» A common practice in programming is to create a function in which we can contain a block of code, then when we wish to use this code, we merely call the function by its name:

```
define :loopy do
 use_bpm 480
 use_synth :dsaw
 play_pattern [ :c3, :c4, :c5, :c6 ]
 sleep 0.5
end
live_loop :testy do
 loopy
end
```

» In our example, we create a function called "loopy," and use the `do...end` construct to store the code that will set the BPM to 480 beats per minute, and play a pattern using `dsaw synth`, before sleeping for half a second. Inside a live_loop, we call the function "loopy" by its name, and the code contained inside is run.

6 USING SAMPLES

The last Sonic Pi concept we're introducing is samples. These are segments of audio that are pre-recorded, and in the music industry, they are used often to embellish a song using clips from classic songs. To use a sample in a new live_loop, we need to recreate the following code below the existing `live_loop :beat`:

```
live_loop :samples do
  sample :loop_amen
  sleep sample_duration :loop_amen
end
```

» The sleep statement for this loop is unusual, because it doesn't have an integer or float value visible. Rather, we instruct Sonic Pi to learn the duration of the sample used, and use that as the sleep value.

7 BUILDING OUR TUNE

Now that we have the basics under our belt, let's start building our composition. Click on a blank workspace, and start your piece by creating a live_loop called "beat." This will contain the code that forms the beat of our piece. Let's put a sample inside the live_loop. When completed, click "Run" to hear the beat.

```
live_loop :beat do
  sample :bd_haus
  sleep 0.5
end
```

» So, our beat is a sample played two times per second, which is a BPM of 120—quite quick and punchy. Let's build upon the beat by creating another live_loop, which will contain a melody. Before we start the live_loop, we add some FX to our audio. To do this, we use the "reverb" FX plugin to add a spacious feel to the notes. We pass the "room 1" argument to instruct Sonic Pi to use the maximum-sized room available—in other words, this gives the sound the maximum available spacious sound. This melody uses the "beep" synth for any notes played.

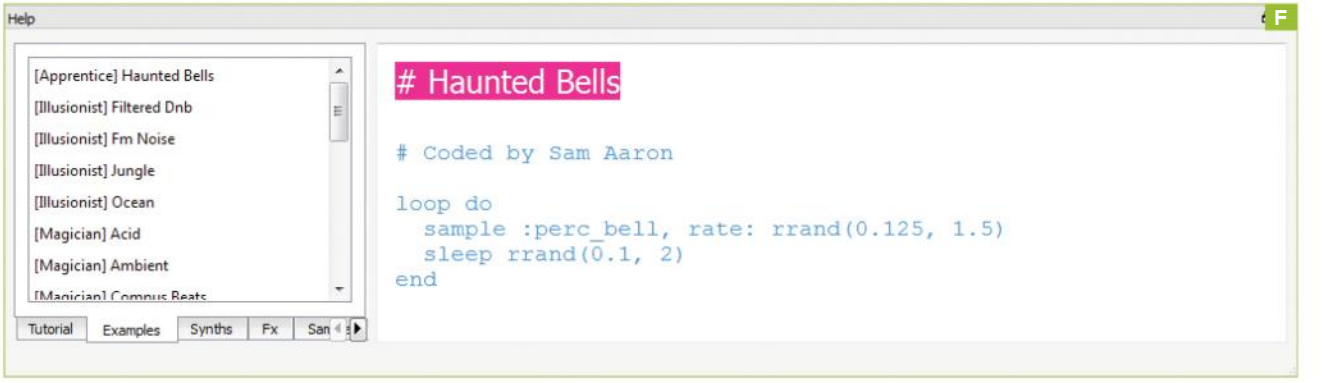
MINECRAFT IN THE MIX!

Minecraft on the Raspberry Pi has become the killer application to teach Python to classes, and Sonic Pi has attained the same status for its use of music. But what if there were a way to merge the musicality of Sonic Pi with the fun of building new worlds in *Minecraft*? Well, now there is, and from version 2.5 of Sonic Pi, you can also integrate *Minecraft* into your musical compositions. At the time of writing, this is still a bleeding-edge feature, but there's already a great deal of functionality available, such as getting the position of the player or a block, changing the position of the player and block type, and posting data to the chat window. The syntax is exceptionally easy to pick up, and integrates seamlessly into the standard Sonic Pi syntax structure, enabling *Minecraft* functionality to be added to any previously written Sonic Pi compositions.

To use Sonic Pi with *Minecraft*, simply open the *Minecraft* application, load a world, open Sonic Pi 2.5, and choose a *Minecraft* function to trigger the connection, such as the chat window:

```
mc_chat_post("Hello World")
```

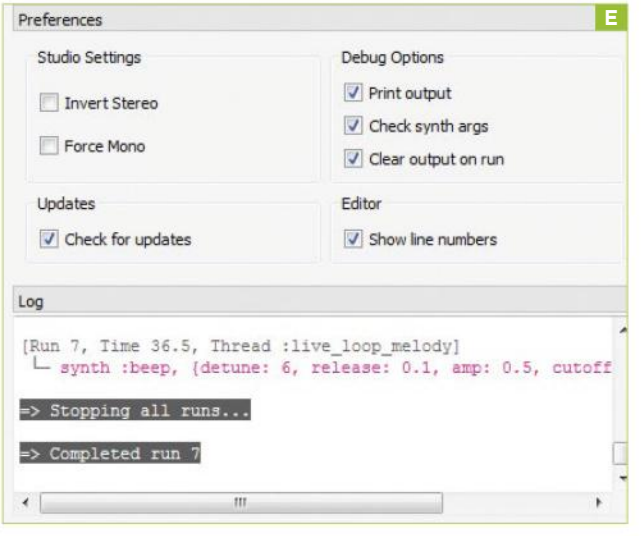
Run the code and—hey presto!—you're connected.



8 USING FX PLUGINS

We then add a seed to the mix, which changes the starting point for any random numbers generated by Sonic Pi. Numbers generated using "random" are never truly random, merely chaotic in nature. We used 66678 as our starting point, but try other numbers to see how the composition changes. Next, we create a variable called "sound," and in there we store a scale of notes in the key of g3. Next, we instruct Sonic Pi to perform the next bank of code 16 times, so it chooses the notes from the "sound" variable, then uses a number of arguments to achieve the following: Detunes the notes to create a slightly off sound to each note; alters the fade out and release of the note, so that it fades quickly; and amp controls the level of the note played—in this case, it's half the volume relative to the others. Then, we modify the cutoff to use a random note between 70 and 80 to cut off certain frequencies. We now instruct the code to wait for 0.125 seconds. Lastly, because we have opened three loops using `do`, we must close them correctly:

```
with_fx :reverb, room: 1  do
 live_loop :melody do
  use_synth :beep
  use_random_seed 66678
  sound = (scale :g3, :major_pentatonic, num_octaves: 3)
  16.times do
   play sound.choose, detune: 6, release: 0.1, amp: 0.5, cutoff:
rrand(70, 80)
   sleep 0.125
  end
 end
end
```



» Click "Run" to play the composition. Remember that you can alter the random seed to produce a different sound. You can also alter the scale of notes, by changing g3 to another scale—g5, c4, and so on. You can also alter `major_pentatonic` to `minor_pentatonic`, to produce a much darker and more sorrowful tone.

9 THE FINALE

Our next live_loop is used to create an ambience to the composition, and again, we're using an FX plugin. This time, it's "ixi_techno," a low-pass filter between the minimum and maximum cutoffs. We call the loop "ambience," and first off, it performs a block of code eight times. Using the "hollow" synth, we play the note c3 with an amplitude of 0.5, putting the note into the mid-tone mix of our composition. We then wait for one second before entering into another loop that iterates eight times. This time, however, it plays the "ambi_choir," a haunting choir sound, at standard speed, but mixed down into the composition, so that it appears as background noise. We then sleep for one second, before closing the four loops that have been created:

```
with_fx :ixi_techno do
 live_loop :ambience do
  8.times do
   use_synth :hollow
   play :c3, amp: 0.5
   sleep 1
   8.times do
    sample :ambi_choir, rate: 1, amp: 0.2
    sleep 1
   end
  end
 end
end
```

» Click "Run" to hear your composition play. Does it need any tweaking to match your goal? You could try changing the sample playback rate from 1 to 0.5, or to 2 for different results.

10 LET THE MUSIC PLAY!

So, using Sonic Pi and some simple coding, we have managed to create a looping piece of audio that can be recorded using the "Record" button, and uploaded to SoundCloud, or used in your YouTube videos.

» There are plenty of Sonic Pi examples on the official website, just point your browser at http://sonic-pi.net and click the "Examples" link. It's also worth checking out the video of Sonic Pi's creator, Sam Aaron, performing live at TEDx Newcastle—you'll find it on the main page.

Set Up a Chat Server on Your Raspberry Pi

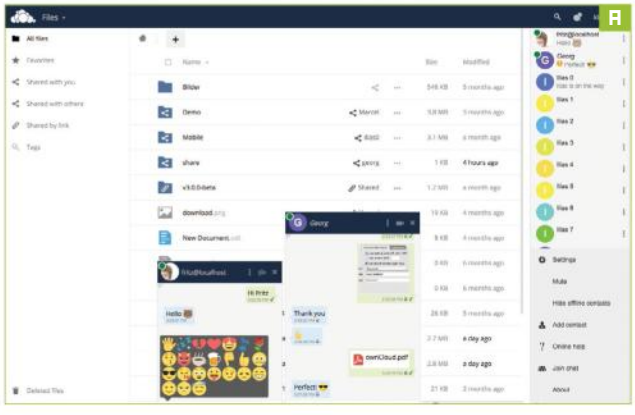
YOU'LL NEED THIS

RASPBERRY PI
See www.raspberrypi.org.

MESSAGING CLIENT
We're using Pidgin, available from www.pidgin.im.

WITH FACEBOOK CHAT, GOOGLE HANGOUTS, Yahoo Messenger, and ICQ, to name but a few, there's certainly no shortage of chat services available nowadays. The downside of all these offerings is that they're closed-source, meaning the code used to design them is not released to the public. This makes it harder to detect security vulnerabilities—plus, you have to trust that big corporates are keeping your private conversations safe.

Federation is also definitely not supported by most proprietary chat software—for instance, someone using the official Google Hangouts app has no way of speaking directly to someone using AOL Messenger. So, how can you get around all these problems? Read on.... **–NATE DRAKE**



1 XMPP TO THE RESCUE

The solution to all of the above is XMPP (Extensible Messaging and Presence Protocol). XMPP is a communications protocol for open-source and secure messaging. Unlike chat software created by big corporations, there's a number of programs you can use to connect to a server running XMPP, and you don't have to share the contents of your conversation with anyone except your contacts.

›› There are thousands of public XMPP servers, some run by large companies and others by private individuals. The Raspberry Pi can easily be used to set up your own XMPP server, to allow your friends, co-workers, or family members to connect and chat together.

›› Part of this project was adapted from a guide put together by Tomas Greno, which can be viewed at http://bit.ly/2dal1Z7.

2 WHY XMPP?

Before starting this project, you may be wondering why you would even want to set up your own chat server on your Raspberry Pi, given the number of alternatives available. You may also be questioning why you would choose XMPP, when you could use more familiar software, such as Facebook Messenger, or have your contacts meet you in an online chatroom. For a full technical rundown of the technologies underlying XMPP, you can visit the Overview page of the XMPP Foundation at http://bit.ly/2d7XrHV. However, in brief, one of the chief advantages of using XMPP to host your own chat server is security—your messages will never leave the server. So, provided your Raspberry Pi never leaves your home or office, it will be much more difficult for someone to read your chat history.

›› Even if you allow others to connect to your Pi chat server over the Internet, you will be using open-source software, which is regularly reviewed by a community of developers, rather than by one team at a single company. This means there is a far greater chance of vulnerabilities being discovered and fixed.

›› XMPP is also extremely flexible. Any XMPP server that is connected to the Internet can communicate with any other user registered with another XMPP server.

›› For example, if you register a chat account with the popular German XMPP server www.jabber.de, you can still communicate with someone who has an account with the British XMPP server www.xmpp.is. Usernames are written in the style of email addresses, such as "hansgruber@jabber.de," and you can add them as contacts in your messaging app [**Image A**].

›› There's a great many XMPP messaging programs available for both computers and mobile devices. Apple's Messages for Mac OS X, and the program Empathy, which comes preinstalled with many versions of Linux, both support the XMPP protocol. For Windows users, it's very easy to download a compatible client.

3 CHOOSE YOUR MESSAGING CLIENT

To connect to your Pi's server, we will be using Pidgin [**Image B**], because it's very flexible and is available for Windows, Mac, and Linux. If you're a Mac or Windows user, head over to www.pidgin.im/download to download Pidgin Messenger. If you're using Linux, simply install it using your OS's package management tool.

›› Although when following the tutorial you will already have added an admin account, this shouldn't be for daily use, so we will create a new account when starting Pidgin.

›› When the Pidgin window opens, select "XMPP" under "Protocol." As we're creating a new account, the username can be anything you want. In the "Domain" field, put the IP address or domain name of your Raspberry Pi, such as "192.168.1.2." The password field can contain any value you like. It's a good idea at this stage to check the "Remember Password" box, to save having to log in each time.

›› The "Local Alias" field is simply the name you wish to appear on your own version of Pidgin, to help you distinguish your account—for example, "Roger-Raspberry-Pi." Check "Create a New Account on this Server," then click "Add."

›› Pidgin is not available for Android devices or iPhones. You can view a full list of XMPP clients for all platforms at http://bit.ly/2d1o2b1. Free apps for iPhone include ChatSecure (see below) and AstraChat. Both are available from the iTunes Store. Cost-free Android XMPP apps

include ChatSecure for Android and Beem, both of which are available in the Google Play Store.

4 PIDGIN PLUGINS

As you will have seen when setting it up, Pidgin supports a number of protocols, such as AOL Instant Messenger, Google Talk, and Yahoo Messenger. It's also highly customizable through the use of extra plugins [Image C]. Some of these plugins, such as Theme Manager, are official, and accessed by clicking the "Tools" menu in Pidgin, then "Plugins." Other plugins have been developed by third parties. A full list of third-party plugins, as well as instructions for installation, is available from http://bit.ly/2cof2P1. One particular plugin of note is Off-the-Record Messaging (OTR).

» In brief, if this plugin is installed in both your copy of Pidgin and that of your friends or colleagues, your conversations are automatically encrypted. Unlike the SSL certificate, which is stored on the Pi, OTR encryption keys never leave your computer, so even the chat server can't keep a meaningful copy of your transcripts.

» If you want to access the chat server securely from a mobile device, try ChatSecure. This free app is available for Android and iPhone, and supports OTR messaging without needing to install extra plugins. More information is available from the Guardian Project's website at http://bit.ly/2cJti6A.

» If you are considering opening your Pi chat server to the Internet, another useful plugin is Bot Sentry. This prevents you from being overwhelmed with spam messages, because you only receive messages from people on your buddy list.

» Once Pidgin is secure, you may want to tweak its appearance, so head over to www.pidginthemes.com.

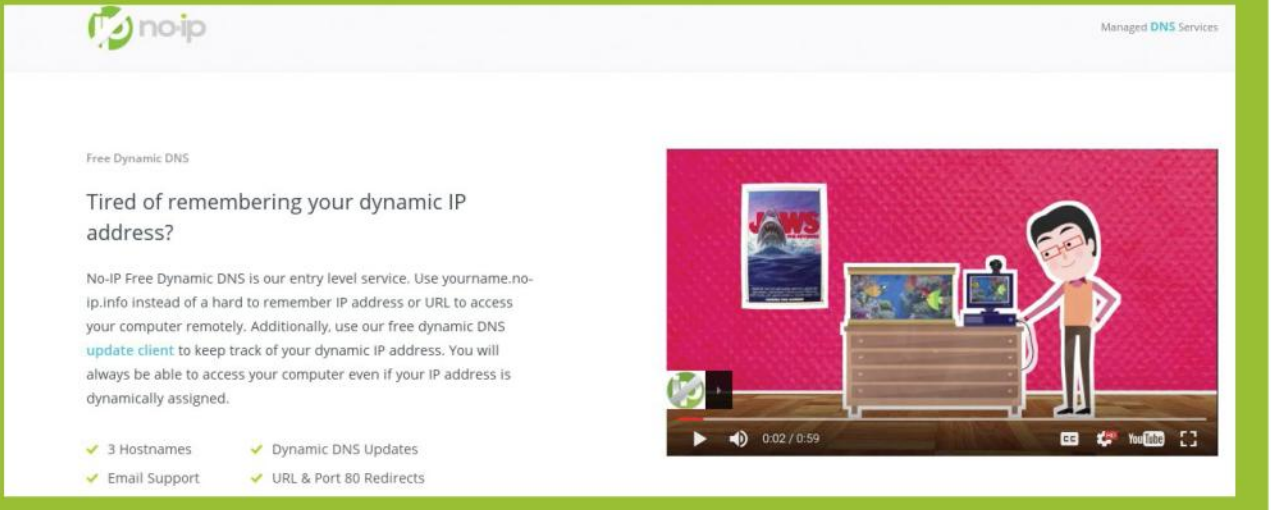
5 CHAT CHALLENGES

As you'll see in the walkthrough (overleaf), the software is very simple to set up and run. If you are having trouble installing the software in the first place, you should make sure you have the latest version of Raspbian. Open Terminal on the Raspberry Pi, or connect via SSH, and run the command `sudo apt-get update` then `sudo apt-get upgrade`. The second command may take some time, so make sure you don't need to use your Raspberry Pi urgently before running.

» As you're going through the walkthrough, you may have difficulty finding the sections you have to edit in the configuration file. Use Ctrl-W to run a search within the file for the sections you need to change—for example, "VirtualHost." Just type your search term and press Return to be taken to the word in question.

» If you restart the Pi for any reason, the Prosody chat service stops. You can get it running again by opening

OPENING YOUR CHATS TO THE WORLD WIDE WEB


no-ip
Managed DNS Services
Free Dynamic DNS
Tired of remembering your dynamic IP address?
No-IP Free Dynamic DNS is our entry level service. Use yourname.no-ip.info instead of a hard to remember IP address or URL to access your computer remotely. Additionally, use our free dynamic DNS update client to keep track of your dynamic IP address. You will always be able to access your computer even if your IP address is dynamically assigned.
3 Hostnames
Dynamic DNS Updates
Email Support
URL & Port 80 Redirects
JAWS
0:02 / 0:59

By default, your chat server will run on your home network only. If you want to communicate with people within your own home or workplace, there's no need to open your Pi to the world.

If you think it would be useful to be able to access the chat server from outside your home or office, first set a static IP address for your Pi, if you haven't already, by following the guide at http://bit.ly/2cCHl8F. Next, you need to obtain a fixed IP address for your router. Your ISP may be able to do this for you for a fee. Alternatively, you can create a hostname that points to your home router through a service such as www.noip.com free of charge. The next step is to open ports 5222 and 5269 on your router. These are the default ports used by XMPP. You need to do this from your router's configuration page. As the steps are different for each router, we cannot provide instructions here, but you can find information on how to forward ports for most common routers at www.portforward.com.

If you do set up a new domain name or IP address for the Pi, be sure to follow Step 2 of the walkthrough (overleaf), to update the domain name/IP in the "Virtual Hosts" section.

Because people will be connecting over the Internet, you may also want to secure your connection with an SSL certificate. (See "Securing Your Chats" box, over the page.)

Terminal on the Pi or connecting via SSH and running the command `sudo /etc/init.d/prosody start`.

6 MORE TROUBLESHOOTING

If you find the software fails to start, try running the command `sudo luac -p prosody.cfg.lua` to check the configuration file. If all is well, the Terminal simply goes on to the next line when you press Return. Otherwise, it tells you the line where there is an error message.

» If you choose to enable SSL, modify the location of both the KEY and CRT file. If you used the Prosody software to generate a self-signed certificate, this is in the same folder. Some messaging clients may display a warning before connecting. This isn't in itself a cause for concern, but it may prevent certain programs from being able to connect.

» If you choose only to access the server from your home or office network, remember that your conversations are only secure if no one can physically access your Raspberry Pi. If you don't use OTR messaging, anyone connected to the network may also be able to read your messages by viewing network traffic. See https://prosody.im/doc/security for a detailed rundown of possible vulnerabilities, as well as suggestions on how to solve them. If you do use OTR messaging, bear in mind that chatrooms are not currently supported.

7 VIDEO ISSUES

Voice and video calls are supported by an extension to the XMPP protocol known as Jingle. Not all XMPP clients support this feature. For instance, voice and video calls are only available from the Apple Mac and Linux versions of Pidgin. Linux's built-in messenger, Empathy, also supports Jingle out of the box, as does Jitsi, which is available for Linux, Mac, and Windows. If your contacts only use Windows, they can download a different client, such as Psi (available from http://psi-im.org), which may support video calling. Alternatively, Windows 10 users can install the Linux version of Pidgin via the Windows 10 Bash shell. See http://bit.ly/1N3Ob2f for details.

» If you have a number of users performing large file transfers or video calling, you may notice the chat server starts responding more slowly. You can relieve this, at least in part, by enabling data compression on your server. See the steps outlined at http://bit.ly/2cPVIJI for more information. Compression is set on a sliding scale from 1 to 9, where 9 is the highest, but uses the most system resources, which in turn could actually slow the Pi down further. We suggest you start at 7, as the Prosody website suggests, and increase as necessary.

8 SHARE THE LOVE

Although XMPP software is very robust and powerful, you may find that some people are reluctant to join your server because they are more familiar with chat services such as Facebook or Google Hangouts, and/or they know how to use those clients. The best remedy is to provide your contacts with some information on the protocol, and what it can do for them. A good place to start is the XMPP Foundation's wiki at http://bit.ly/2clH7ld.

» If you do persuade people to use your chat server, you may want to set up a dedicated chatroom for everyone. You need to specify this in your configuration file. Visit http://bit.ly/2ctr9ZL for details of how to do this.

» Prosody is extremely lightweight, which makes it ideal for running on the Raspberry Pi. The downside to this is that you may need special features that aren't available. One example would be the ability to broadcast a message to everyone who is online, which isn't natively supported. Fortunately, there is a large number of add-ons for Prosody, known as modules. Head over to https://modules.prosody.im to see a list of those available. If you see any you think would be useful, download them to your Pi, and follow the steps at http://bit.ly/2ctqpne to install them. You may need to restart the Raspberry Pi for the module(s) to take effect.

SECURING YOUR CHATS

If you want to be sure your connection is safe, you can use an SSL certificate to encrypt the connection each time your messaging client passes the password to the Raspberry Pi.

If you wish to connect your Pi's chat server to the Internet, it's best to obtain your certificate from a legitimate certificate authority. This also makes it easier for your chat server to authenticate itself to other XMPP chat servers over the Internet.

Alternatively, you can generate your own self-signed certificate. This is generally considered less secure, and some XMPP messaging programs may refuse to connect to it, but it's easier to set up. First, open Terminal on the Pi, or connect via SSH, and run the command:

```
sudo prosodyctl cert generate yourhostname
```

For example:

```
sudo prosodyctl cert generate 192.168.1.2
```

You are asked a series of questions, such as your key size, country, and so on. Press Return to accept the default options, except when you're asked for the "Common Name." Here, type your chat server's IP address—"192.168.1.2," for example. When done, the system tells you where it has stored the CRT file. Make a note of this. Next, open the Prosody configuration file with the command:

```
sudo nano /etc/prosody/prosody.cfg.lua
```

Scroll down to the section marked `ssl =` and edit with the correct path to your files, such as:

```
ssl = {
  key = "/var/lib/prosody/192.168.1.2.key";
  certificate = "/var/lib/prosody/192.168.1.2.crt";
}
```

Press Ctrl-X, then Y, then hit Return to save your changes.

SET UP YOUR CHAT SERVER

The programs included with the Debian GNU/Linux system are free softwar
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Fri Aug 19 14:14:44 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo apt-get install prosody
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
lua-event lua-expat lua-filesystem lua-sec lua-socket ssl-cert
Suggested packages:
lua-zlib lua-dbi-postgresql lua-dbi-mysql lua-dbi-sqlite3 openssl-bla
Recommended packages:
lua5.1-sec lua5.1-event
The following NEW packages will be installed:
lua-event lua-expat lua-filesystem lua-sec lua-socket prosody ssl-cer

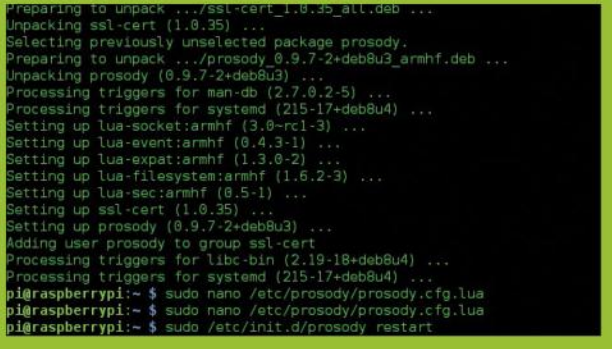
1. INSTALL PROSODY

Open Terminal on your Raspberry Pi, or connect via SSH, and run the command `sudo apt-get install prosody`, then press Y to confirm you want to install the software on your device. In the next step, you'll need to change your configuration, so run `sudo nano /etc/prosody/prosody.cfg.lua`.

GNU nano 2.2.6 File: /etc/prosody/prosody.cfg.lua
-- Logs errors to syslog also
log = {
-- Log files (change 'info' to 'debug' for debug logs):
info = "/var/log/prosody/prosody.log";
error = "/var/log/prosody/prosody.err";
-- Syslog:
{ levels = { "error" }; to = "syslog"; };
}
---------- Virtual hosts ----------
-- You need to add a VirtualHost entry for each domain you wish Prosody
-- Settings under each VirtualHost entry apply *only* to that host.
VirtualHost "192.168.1.2"
-- Assign this host a certificate for TLS, otherwise it would u
-- set in the global section (if any).
-- Note that old-style SSL on port 5223 only supports one certi

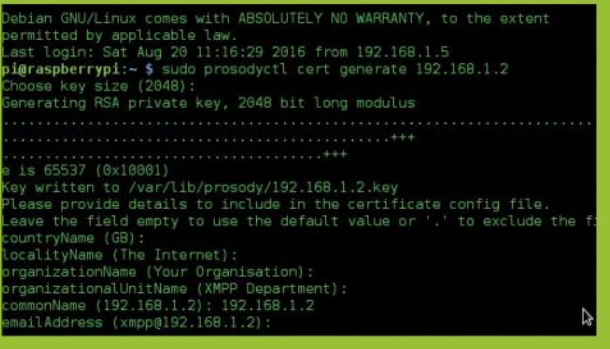
2. MODIFY CONFIG FILE

Scroll to the section labeled "Virtual Hosts" and change `example.com` to your domain—for example, `192.168.1.2`. Scroll up to the section named "Server Wide Settings" and, under "Admins," change, to `admins = {"admin@yourip"}` — for example, `admins = {"admin@192.168.1.2"}`. Next, search for the words "allow_registration" and change to `true`. Press Ctrl-X, Y, then Return to save and exit.


Preparing to unpack .../ssl-cert_1.0.35_all.deb ...
Unpacking ssl-cert (1.0.35) ...
Selecting previously unselected package prosody.
Preparing to unpack .../prosody_0.9.7-2+deb8u3_armhf.deb ...
Unpacking prosody (0.9.7-2+deb8u3) ...
Processing triggers for man-db (2.7.0.2-5) ...
Processing triggers for systemd (215-17+deb8u4) ...
Setting up lua-socket:armhf (3.0~rc1-3) ...
Setting up lua-event:armhf (0.4.3-1) ...
Setting up lua-expat:armhf (1.3.0-2) ...
Setting up lua-filesystem:armhf (1.6.2-3) ...
Setting up lua-sec:armhf (0.5-1) ...
Setting up ssl-cert (1.0.35) ...
Setting up prosody (0.9.7-2+deb8u3) ...
Adding user prosody to group ssl-cert
Processing triggers for libc-bin (2.19-18+deb8u4) ...
Processing triggers for systemd (215-17+deb8u4) ...
pi@raspberrypi:~ $ sudo nano /etc/prosody/prosody.cfg.lua
pi@raspberrypi:~ $ sudo nano /etc/prosody/prosody.cfg.lua
pi@raspberrypi:~ $ sudo /etc/init.d/prosody restart

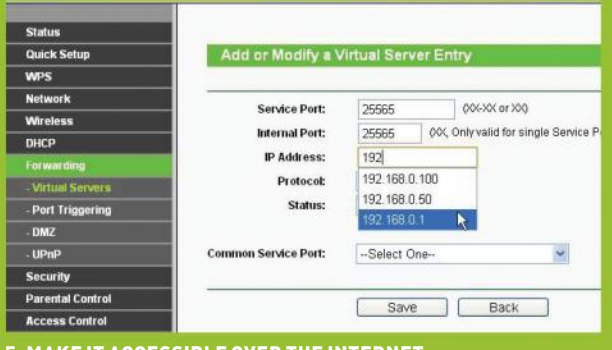
3. RESTART AND ADD AN ADMINISTRATOR

Run the command `sudo /etc/init.d/prosody restart` to restart Prosody. Next, add an administrator account with the command `sudo prosodyctl adduser admin@yourdomain`—for example, `sudo prosodyctl adduser admin@192.168.1.2`. You're asked to type an administrator password. Do so, and press Return. Retype the password, then press Return once again.


Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Sat Aug 20 11:16:29 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo prosodyctl cert generate 192.168.1.2
Choose key size (2048):
Generating RSA private key, 2048 bit long modulus
e is 65537 (0x10001)
Key written to /var/lib/prosody/192.168.1.2.key
Please provide details to include in the certificate config file.
countryName (GB):
localityName (The Internet):
organizationName (Your Organisation):
organizationalUnitName (XMPP Department):
commonName (192.168.1.2): 192.168.1.2
emailAddress (xmpp@192.168.1.2):

4. GENERATE AN SSL CERTIFICATE

This step is optional, but recommended. At this stage, you may wish to generate an SSL certificate to allow messaging clients to connect securely to your server. Follow the steps in "Securing Your Chats" (opposite) to do this.



5. MAKE IT ACCESSIBLE OVER THE INTERNET

If you only want to use the chat server in your home or office, this step isn't necessary. However, if you want to be able to chat to people in the world at large, follow the steps outlined in "Opening Your Chats to the World Wide Web" (see page 61).

6. CONNECT WITH AN XMPP CLIENT

Finally, use Pidgin, or another XMPP-compatible program, to connect to your chat server. Provide the details to your friends or co-workers to make sure that they can connect, too. And that's it—you're ready to chat away to your heart's content.

Control Your RPi With Your Voice

YOU'LL NEED THIS

RASPBERRY PI
See www.raspberrypi.org.

MICROPHONE
A USB model or a webcam with built-in mic.

IN STAR TREK IV: *The Voyage Home*, Scotty and Dr McCoy are offered the opportunity to use a computer, and are somewhat bemused when it fails to respond to voice commands. The film was made 30 years ago, and voice recognition has taken huge leaps forward since then. The Raspberry Pi has not been left out, and with the help of an inexpensive USB microphone [**Image A**] and some suitable software, you too can have your Pi search YouTube, open web pages, launch applications, and even respond to questions, simply by speaking.

The Pi has no built-in soundcard or audio jack, so you need a USB microphone or a webcam with built-in mic for this project. We tested the software using a Microsoft HD-3000 webcam, but any compatible device will do. Visit http://elinux.org/RPi_USB_Webcams for a full list of Pi-compatible webcams, but be sure that whatever device you choose has an integrated microphone. **–NATE DRAKE**

A

1 WHAT YOU NEED

If you only have a microphone with an audio jack, try searching Amazon or eBay for an inexpensive USB soundcard [**Image B**], which plugs into the USB port at one end, and has an output for earphones and a microphone at the other.

» There's a number of speech recognition programs available for the Raspberry Pi. For this project, we're using Steven Hickson's Pi AUI Suite, because it's powerful as well as extremely easy to set up and configure.

2 GETTING STARTED

Once you follow the steps in the walkthrough (overleaf), you will be able to start the installer. The Pi AUI Suite gives you a choice of a number of programs to install. The first question you are asked is whether it should install the dependencies. These, quite simply, are the files the Raspberry Pi needs to download for voice commands to work, so select "Y" and press Return to agree to this.

» Next, you are asked if you want to install the PlayVideo program, which enables you to use voice commands to launch and play video files. If you choose "Y," you're asked to specify the path to your media files—for example, "/home/pi/Videos." Note that upper-case letters are important here. If the path is invalid, the program warns you.

» You're then asked if you want to install the Downloader program, which searches for and automatically downloads files from the Internet for you. If you choose "Y" here, you're asked to provide settings for host, port, username, and password. If you aren't sure of these, press Return for now to choose the default options in each case. The following program is Google Text to Speech Service, which you may wish to install if you want the Pi to read out the content of text files. In order to use this service, the Raspberry Pi needs to be connected to the Internet, because it connects to Google's servers to "translate" the text into speech, and then plays an audio file with the Pi's media player.

» If you decide to install this, you need a Google account. The installer asks you to enter your username. Do so, then press Return. You're then prompted for your Google password. Enter this, and press Return again.

3 MORE SOFTWARE OPTIONS

The installer also offers you the chance to install Google Voice Commands. This uses Google's own speech recognition service. Again, you're asked to provide your Google username and password to continue. Whether or not you choose the Google-specific software, the program also asks whether you want to install the YouTube scripts. These tools enable you to speak a phrase such as "YouTube fluffy kittens," which then causes a relevant video clip to be played.

» Finally, the program gives you the option to install Voicecommand, which contains some of the more useful scripts, such as being able to launch your web browser by saying the word "Internet."

» The program asks you if you want Voicecommand to set itself up automatically. If you experience an error at this stage, follow Step 3 of the walkthrough (overleaf).

4 TWEAK THE SETUP

Once the Voicecommand program is installed, you may wish to make a few basic changes to the setup before fine-tuning your configuration.

» Open Terminal on your Pi or connect via SSH and run the command `sudo voicecommand -s`.

» You are asked a series of yes/no questions next. The first question asks whether you want to permanently set the continuous flag. In plain English, the Voicecommand program is asking whether, each time you run it, you want it to continuously listen for your voice commands. Select "Y" for now. Next, you are asked whether you want the Voicecommand program to permanently set the verify

B

flag. Selecting "Y" here means the program expects you to say your keyword (by default, the word "Pi") before responding to your commands. This can be useful if you want to set the Raspberry Pi to listen continuously, and don't want it to act on everything you say out loud.

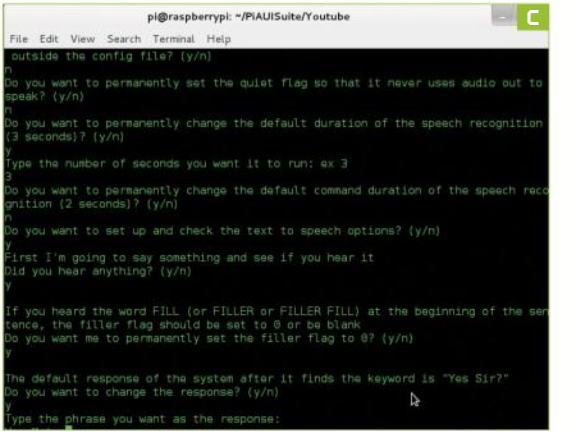
» The following prompt asks if you want to permanently set the ignore flag. This means that if Voicecommand hears a command that's not specifically listed in your configuration file, it tries to look for a program in your installed applications and run it. For instance, if you say the word "leafpad," which is a notepad application, Voicecommand searches for and runs this even if not specifically told to.

» We do not recommend you enable this feature. Because you're running Voicecommand as a SuperUser, there's too much risk that you could inadvertently tell the Pi a command that could harm your files. If you want to set up extra apps to work with Voicecommand, you can edit the configuration file in each specific case. (See "Voice Command Tweaks," over the page, for more information.)

» Voicecommand then asks you whether you wish to permanently set the quiet flag, so it doesn't give a verbal response when you speak. Choose "Y" or "N" as you see fit.

5 MAKE YOUR PI TALK

Next, you're asked if you want to change the default duration for speech recognition. You should only change this if you're finding the Pi is having trouble hearing your commands. If you choose "Y," you're asked to type in a number—this is the number of seconds that the Pi listens for a voice command, and the default is 3. The program then gives you a chance to set up the text-to-speech options. Turn up your volume before doing this. The program


pi@raspberrypi: ~/PiAUISuite/Youtube
File Edit View Search Terminal Help
outside the config file? (y/n)
n
Do you want to permanently set the quiet flag so that it never uses audio out to speak? (y/n)
n
Do you want to permanently change the default duration of the speech recognition (3 seconds)? (y/n)
y
Type the number of seconds you want it to run: ex 3
3
Do you want to permanently change the default command duration of the speech recognition (2 seconds)? (y/n)
n
Do you want to set up and check the text to speech options? (y/n)
y
First I'm going to say something and see if you hear it
Did you hear anything? (y/n)
y
If you heard the word FILL (or FILLER or FILLER FILL) at the beginning of the sentence, the filler flag should be set to 0 or be blank
Do you want me to permanently set the filler flag to 0? (y/n)
y
The default response of the system after it finds the keyword is "Yes Sir?"
Do you want to change the response? (y/n)
y
Type the phrase you want as the response:
C

attempts to say something, and asks whether you have heard it.

» The default response of the system when responding to your keyword is "Yes sir?" Choose "Y" on the next prompt to change this, then type in your desired response, such as "Yes ma'am?" [**Image C**]. Press Return when you're done. The system plays back the response for you to confirm whether you're happy with the result.

» The procedure is the same for the default message for when the system receives an unknown command. The default response is "Received improper command," but you can change this to something less robotic if you prefer, by typing "Y," then your chosen response—for example, "Unknown command."

6 TALK AWAY!

You are now offered the chance to set up the speech recognition options. This automatically checks whether you have a compatible microphone installed in your Raspberry Pi. Voicecommand next asks you whether you want the Pi to check your audio threshold for you. Make sure there is no background noise, press "Y," then hit Return.

» It then asks you to speak a command to check that it has the correct audio device selected. The program automatically determines the right audio threshold for you, so type "Y" to choose this.

» Finally, the Pi asks you if you want to change the default keyword ("Pi") to activate voice commands. Type "Y," then enter your new keyword. Press Return when

BASIC VOICE COMMANDS

Once installation of the Raspberry Pi AUI Suite is complete and you have run `sudo voicecommand -c` to set it to listen, you need to prime it with a keyword. By default, the keyword is "Pi," but feel free to alter this to something easier, such as the word "Jessie."

Next, you should try out a few of the built-in voice commands.

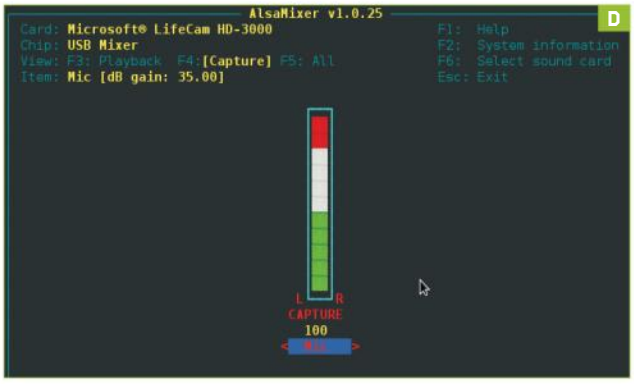
YOUTUBE: Saying "YouTube" and a video title automatically loads a full-screen video of the first relevant YouTube clip. This is similar to Google's "I'm feeling lucky." Say "YouTube" and the name of the video in which you're interested—for example, "YouTube fluffy kittens."

INTERNET: Saying the word "Internet" launches your web browser. By default, this is the Pi's built-in browser Midori, although you can change this.

DOWNLOAD: Saying the word "download" plus a search term automatically searches the Pirate Bay website for the file in question—for example, you could say "Download Ubuntu Yakkety Yak" to get the latest version of the Ubuntu Linux operating system.

PLAY: This command uses the built-in media player to play a music or video file—for example, "Play mozartconcert.mp4" would play that particular file located in the media folder you specified in setup, such as /home/pi/Videos.

SHOW ME: Saying "show me" opens up a folder of your choice. By default, the command doesn't go to a valid folder, so you need to edit your configuration file to a valid location—for example, `show me==/home/pi/Documents`.



done. You are then asked to speak your keyword to acclimatize the Pi to your speaking voice. If this seems correct, type "Y" to complete the setup. Follow Step 6 of the tutorial opposite to run the Voicecommand software. Try to start out with a few simple commands. (See "Basic Voice Commands," on the previous page, for more information.) Once you're comfortable with these, run the command `sudo killall voicecommand` to shut down the program, and edit your configuration file if you wish.

7 VEXING VOICES

Voice recognition software is a work in progress, and the Pi may not recognize everything you say. To improve your chances, be sure to stay near the USB microphone, and speak slowly and clearly.

» If you're still having trouble being understood, open Terminal on your Pi or connect via SSH and run the command `alsamixer` to open your sound settings. Press F4 to choose audio input, then press F6. Use the arrow keys to select your USB device, then press Return. This controls the volume of your USB microphone. Use the up arrow to push it to maximum (100) [**Image D**].

» If your USB microphone isn't being detected at all, it might need more power than the Raspberry Pi's USB ports can provide on their own. The best solution to get round this is to use a powered USB hub. The Pi Supply website sells a seven-port powered hub for just $13 (http://bit.ly/2c8H10y). A powered USB hub can also be useful if you want to use an external hard drive with your Raspberry Pi.

8 TROUBLESHOOTING TIPS

Once the Download program is installed, if you experience an error connecting, bear in mind that access to the certain torrent sites may be restricted where you are. In order to download files, you also need a BitTorrent client for the Pi, such as the program Transmission. You can install this by opening Terminal or connecting to your Pi over SSH and running the command `sudo apt-get install transmission`. Help with getting started and how to use the client is available from the Transmission website at https://forum.transmissionbt.com. Needless to say, you should only download files with the permission of the copyright holder.

» If you choose to use Google Voice Commands or Google TTS (Text to Speech), bear in mind that anything you say and any text files you submit are sent to Google's servers for translation. Google claims not to retain any of this data, but even if it is to be believed, any data transmitted over the Internet can potentially be intercepted by a third party. Google does encrypt your connection to reduce the chance of this happening, however.

» If you find you're happy with the voice command feature, you might prefer the software to start automatically each time you boot the Pi. If so, open Terminal on your Pi or connect via SSH and run the following command:

```
nsudo nano /etc/rc.local
```

» This opens the file that determines which processes start up when your Raspberry Pi boots. By default, this script does nothing. Use your arrow keys to scroll to the bottom of the file and, just above the line reading `exit 0`, type the following:

```
sudo voicecommand -c
```

» Press Ctrl-X, then Y, then Return to save your changes. Feel free to reboot the Pi at this stage to make sure it works. If you're unsure whether Voicecommand is running, open Terminal and run the command `ps -a` to show a list of running processes.

VOICE COMMAND TWEAKS

Once your Voicecommand software is up and running, you can edit the configuration file to add new commands or modify existing ones.

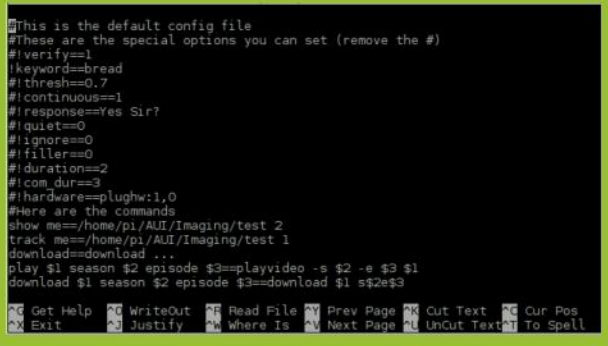
Run the command `sudo nano /root/.commands.conf` to view the configuration file. As you'll see, most of the lines begin with a `#` symbol, which means the Pi ignores them. Delete the symbol to activate the line. If, for instance, you want to change the keyword that activates the voice recognition software from "Pi" to "Jessie," you would change the line from `#!keyword==pi` to `-!keyword=jessie`.

If you use the Firefox web browser instead of Midori on your Raspberry Pi, you may also want to change `~Internet==midori &` to `~Internet==firefox-esr &`.

The software can run any command. For instance, to open the desktop by saying the word "desktop," add the following line to the end of the file: `desktop==home/pi/Desktop`. You can also launch programs as you would from the terminal—for example, `notepad==leafpad`.

As you're talking to your Raspberry Pi, you may want it to respond to you with speech. Do this first by opening Terminal and installing the speech synthesis software Festival with the following command:

```
sudo apt-get install festival
```


#This is the default config file
#These are the special options you can set (remove the #)
#!verify==1
!keyword==bread
#!thresh==0.7
#!continuous==1
#!response==Yes Sir?
#!quiet==0
#!ignore==0
#!filler==0
#!duration==2
#!com_dur==3
#!hardware==plughw:1,0
#Here are the commands
show me==/home/pi/AUI/Imaging/test 2
track me==/home/pi/AUI/Imaging/test 1
download==download ...
play $1 season $2 episode $3==playvideo -s $2 -e $3 $1
download $1 season $2 episode $3==download $1 s$2e$3
^G Get Help ^O WriteOut ^R Read File ^Y Prev Page ^K Cut Text ^C Cur Pos
^X Exit ^J Justify ^W Where Is ^V Next Page ^U UnCut Text ^T To Spell

The basic format to get the Raspberry Pi to talk is `echo "Your message here" | festival –tts`. You can also have the Pi read out system information. For example, if you wanted the Pi to tell you the date and time, you would need to add the following line to the config file:

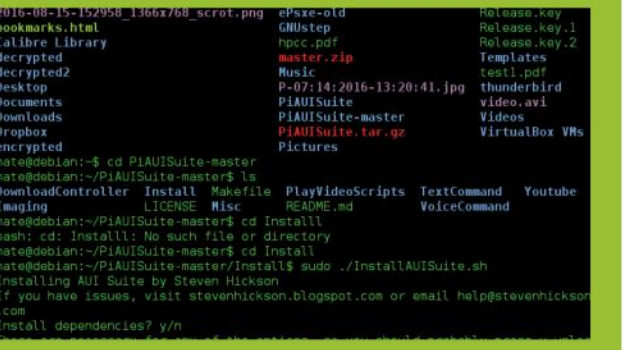
```
time==echo "The time is" | festival --tts && date | festival –tts
```

SET UP VOICE COMMANDS ON YOUR PI

nate@debian:~$ ssh pi@192.168.1.123
pi@192.168.1.123's password:
The programs included with the Debian GNU/Linux system are free software
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:37:26 2016 from 192.168.1.5
pi@raspberrypi:~ $ git clone git://github.com/StevenHickson/PiAUISuite.g
Cloning into 'PiAUISuite'...
remote: Counting objects: 802, done.
remote: Total 802 (delta 0), reused 0 (delta 0), pack-reused 802
Receiving objects: 100% (802/802), 4.14 MiB | 1.30 MiB/s, done.
Resolving deltas: 100% (475/475), done.
Checking connectivity... done.
pi@raspberrypi:~ $ cd PiAUISuite/Install
pi@raspberrypi:~/PiAUISuite/Install $

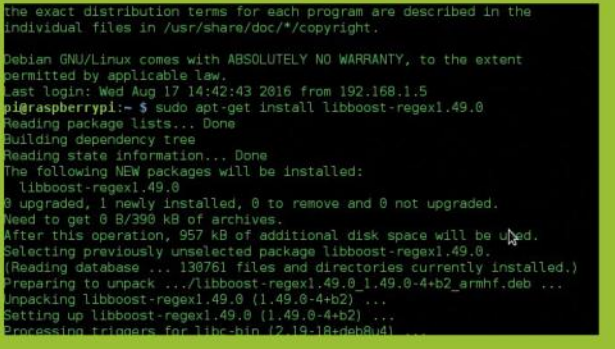
1. DOWNLOAD INSTALLATION FILES

Open Terminal on your Raspberry Pi or connect via SSH and download the installation files by running the command `git clone git: //github.com/StevenHickson/PiAUISuite.git`. When the download is complete run `cd PiAUISuite/Install` to open the installation directory.



2. RUN THE INSTALLER

Use the command `sudo ./InstallAUISuite.sh` to run the text installer. Choose `y` to install any dependencies, and then work your way through the installation wizard. See the main article for more details about how to do this.


the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:42:43 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo apt-get install libboost-regex1.49.0
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
libboost-regex1.49.0
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 0 B/390 kB of archives.
After this operation, 957 kB of additional disk space will be used.
Selecting previously unselected package libboost-regex1.49.0.
(Reading database ... 130761 files and directories currently installed.)
Preparing to unpack .../libboost-regex1.49.0_1.49.0-4+b2_armhf.deb ...
Unpacking libboost-regex1.49.0 (1.49.0-4+b2) ...
Setting up libboost-regex1.49.0 (1.49.0-4+b2) ...
Processing triggers for libc-bin (2.19-18+deb8u4) ...

3. INSTALL BOOST C++ LIBRARY

If you encounter an error when trying to set up the Voicecommand program, run `sudo apt-get install libboost-regex1.49.0` to install the necessary software. Next, run `sudo ./InstallAUISuite.sh` to run the installer again.

nate@debian:~$ ssh pi@192.168.1.123
pi@192.168.1.123's password:
The programs included with the Debian GNU/Linux system are free so
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:43:19 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo mv /home/pi/.commands.conf /root/.commands
pi@raspberrypi:~ $

4. COPY CONFIGURATION FILES

Because you're going to be running the Voicecommand program as the root user, you need to use the command `sudo mv /home/pi/.commands.conf /root/.commands.conf` to copy across the necessary configuration files.

5. EDIT CONFIG FILE

Use the command `sudo nano /root/.commands.conf` to inspect your configuration file. You can now change your keyword or add extra commands. (See "Voice Command Tweaks," opposite, for more information.)

nate@debian:~$ ssh pi@192.168.1.123
pi@192.168.1.123's password:
The programs included with the Debian GNU/Linux system are free so
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Wed Aug 17 14:46:37 2016 from 192.168.1.5
pi@raspberrypi:~ $ sudo voicecommand -c
Opening config file...
running in continuous mode
keyword duration is 2 and duration is 3

6. RUN VOICECOMMAND

Use the command `sudo voicecommand -c` to start the software. It automatically listens out for your keyword. You can then give it further commands, such as "YouTube fluffy kittens."

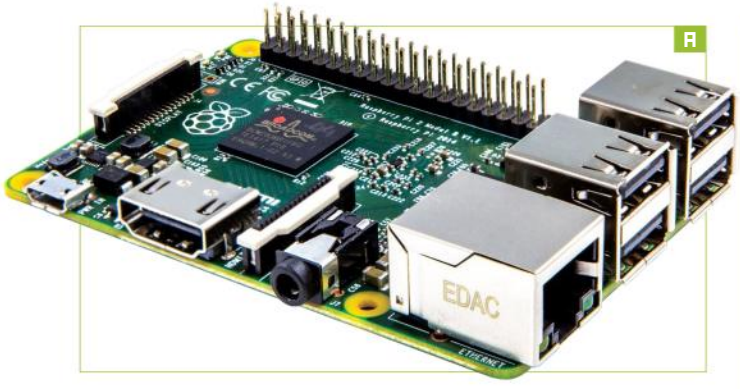
Create a Pi Cloud with OwnCloud

YOU'LL NEED THIS

RASPBERRY PI AND SD CARD/USB DISK
See www.raspberrypi.org.

OWNCLOUD
Download it from www.owncloud.org.

THERE ARE PLENTY OF CLOUD file storage and sharing services, so why would you want the hassle of setting up your own? There are many reasons, beyond the perfectly acceptable "because you can." Commercial services have limits on the amount of data you can store. They may or may not encrypt your data, but it is their encryption—you can't be sure that they can't read it. If you're sharing between computers on the same network, your data still has to go to their server, over a relatively slow upstream link, before it can be downloaded to another computer in the next room. On the other hand, commercial providers have large data farms, with plenty of redundant storage and connectivity, and, usually, comprehensive backup procedures. If you want to run your own cloud storage, you have to take responsibility for that. –NEIL BOTHWICK



1 ESSENTIAL GEAR

You're still reading, so we assume you are interested in doing this. The three things you need are: an always-on computer, some suitable software, and a decent amount of storage space. The first one could be any Linux computer you leave turned on, but we are going to use a Raspberry Pi for this [Image A]. It's ideally suited for the low-powered, always-on needs of a home network. You may have heard of the software, it's called OwnCloud (www.owncloud.org), and for the storage space, you need to add some to the Raspberry Pi. For initial testing, a decent-sized SD card will give sufficient storage. As your storage needs grow, a USB external disk may be called for.

2 SETTING UP THE PI

We are going to use the latest version of Raspbian on the Pi, although these instructions work with any distro based on Debian, so you could equally follow them on an Ubuntu desktop. Download the latest Raspbian Lite image from www.raspberrypi.org/downloads/raspbian, and copy it to an SD card. Then put in it the Raspberry Pi, and fire it up. Raspbian Lite is a headless version, which means all commands are entered in an SSH session, so open a terminal on your computer, and run:

```
$ ssh pi@IP-ADDRESS
```

using the IP address of your Pi. The default password is "raspberry," so the first thing to do is run:

```
$ sudo raspi-config
```

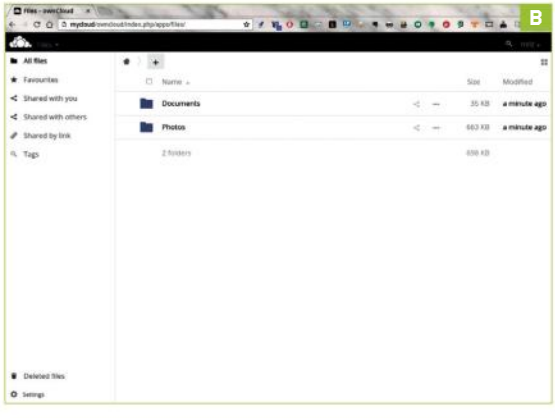
and change the password to something else. Then select the option to resize the filesystem to fit your SD card. You should also go into the advanced options section, and give the Pi a hostname. When you exit raspi-config and reboot, it should then be accessible using the hostname you gave it (although this does depend on your router).

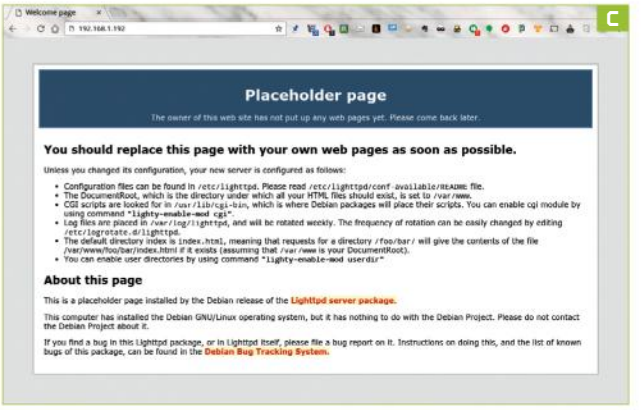
›› Your Raspberry Pi is assigned an IP address by your router's DHCP server. While such addresses are assigned dynamically, DHCP servers generally remember which address they gave to which hardware, and give the same one each time. You can set up your server to use a static IP address, of course, but it's generally not necessary, especially if you set a hostname in raspi-config to give the Raspberry Pi a useful name. This is the local address we are talking about—some sort of static address or domain is needed if you want to be able to connect to your cloud storage from outside of your network. If you don't have a static address, one of the dynamic DNS services would be useful.

3 INSTALL A WEB SERVER

OwnCloud is a web application [Image B], so it needs a web server to run it. Apache is the most popular web server, but it's a bit heavyweight for a Pi, especially as we don't need all its capabilities. Lightweight, but very functional, alternatives include lighttpd (www.lighttpd.net) and Nginx (http://nginx.org)—we are using the former here. SSH into your Pi, make sure everything is up to date, then install lighttpd (known to its friends as "lighty"), and the required PHP modules with:

```
$ apt-get update
$ apt-get upgrade
```




Welcome page
192.168.1.192
Placeholder page
The owner of this web site has not put up any web pages yet. Please come back later.
You should replace this page with your own web pages as soon as possible.
Unless you changed its configuration, your new server is configured as follows:
Configuration files can be found in /etc/lighttpd. Please read /etc/lighttpd/conf-available/README file.
The DocumentRoot, which is the directory under which all your HTML files should exist, is set to /var/www.
CGI scripts are looked for in /usr/lib/cgi-bin, which is where Debian packages will place their scripts. You can enable cgi module by using command "lighty-enable-mod cgi".
Log files are placed in /var/log/lighttpd, and will be rotated weekly. The frequency of rotation can be easily changed by editing /etc/logrotate.d/lighttpd.
The default directory index is index.html, meaning that requests for a directory /foo/bar/ will give the contents of the file /var/www/foo/bar/index.html if it exists (assuming that /var/www is your DocumentRoot).
You can enable user directories by using command "lighty-enable-mod userdir"
About this page
This is a placeholder page installed by the Debian release of the Lighttpd server package.
This computer has installed the Debian GNU/Linux operating system, but it has nothing to do with the Debian Project. Please do not contact the Debian Project about it.
If you find a bug in this Lighttpd package, or in Lighttpd itself, please file a bug report on it. Instructions on doing this, and the list of known bugs of this package, can be found in the Debian Bug Tracking System.

```
$ apt-get install lighttpd php5-cgi php5-gd php5-curl php5-sqlite
```

» Now point a browser at http://<IP-ADDRESS-OF-PI>, and you'll see the lighttpd placeholder page [**Image C**]. We'll disable access to this later on, after we've set up the homepage.

» Now it's time to install OwnCloud, which is basically a case of unpacking the tarball into the web server's DocumentRoot—the directory from which it serves files. In the Raspbian install of lighttpd, this is /var/www/html, so unpack the tarball with:

```
$ sudo tar -C /var/www/html -xf owncloud-9.0.2.tar.bz2
```

4 INSTALLING OWNCLOUD

OwnCloud defaults to storing its data inside its DocumentRoot, which isn't particularly secure. It's safer to create a directory elsewhere for this, and make it owned by the user running the web server—www-data for Debian systems.

```
$ sudo mkdir -p /var/owncloud/data
$ sudo chown -R www-data: /var/owncloud
```

» The server also needs write access to some directories in the DocumentRoot, which you do with this command:

```
$ sudo chown -R www-data: /var/www/html/owncloud/{apps,config,themes,updater,.user.ini}
```

» Don't be tempted to simply chown the whole Owncloud directory; it's more secure if you only allow the web server to write to the directories it needs to. If you try to open http://IP-ADDRESS/owncloud in your browser, you get a "Forbidden" error, so there's clearly some more configuration to do. There are various pre-made configurations in /etc/lighttpd/conf-available. You enable them with the `lighttpd-enable-mod` command, which symlinks them into the conf-enabled directory. Run:

```
$ sudo lighttpd-enable-mod accesslog
$ sudo lighttpd-enable-mod fastcgi
$ sudo lighttpd-enable-mod fastcgi-php
```

then restart the server with:

```
$ sudo systemctl restart lighttpd
```

and reload the page in your browser. Here you are asked to create an admin user and password, Click on "Storage & database" below this, and change the data folder to /var/owncloud/data. After a bit of whirring and clicking (well, the Pi is silent, but that's what it feels like), the OwnCloud homepage shows up. At this point, you can create folders and upload files by clicking the "+" icon above the file list.

» At the top-right of the display, you will see your username as a drop-down menu. As your user is also the admin, this menu has extra options—for example, you can create users and groups (these are for OwnCloud only, not to be confused with system users and groups). There is also an admin option, and selecting this loads a page with various settings and a couple of warnings at the top. The first warns you that you are using HTTP and not HTTPS to transfer files. This is not a problem if you are only running OwnCloud on your private LAN, and it does make life a little easier for the Pi. If you are sharing files over the Internet, using HTTPS is a good idea, and is covered later on.

5 OWNCLOUD ADMIN

The other warning is about a memory cache. This isn't required, but does speed things up. To set this up, install the APCu (Alternative PHP Cache) program and then restart the server:

```
$ sudo apt-get install php5-apcu
$ sudo systemctl restart lighttpd
```

» Then enable the cache in OwnCloud by editing /var/www/html/owncloud/config/config.php and adding `'memcache.local' => '\OC\Memcache\APCu` to the end of the file, just before the final closing parenthesis. After editing, the end of the file should look like:

```
'installed' => true,
'memcache.local' => '\OC\Memcache\APCu',
);
```

PICK A DATABASE

As well as a web server, OwnCloud also needs a database. You have two main choices here: MySQL or SQLite. SQLite is simple and lightweight, and perfectly sufficient for a small home setup, and that's what we've used in the instructions here. There are a few reasons for using MySQL instead, however—for instance, you may want a larger setup serving several users, or you are already running MySQL on your computer, in which case, it's more efficient to use a single database server.

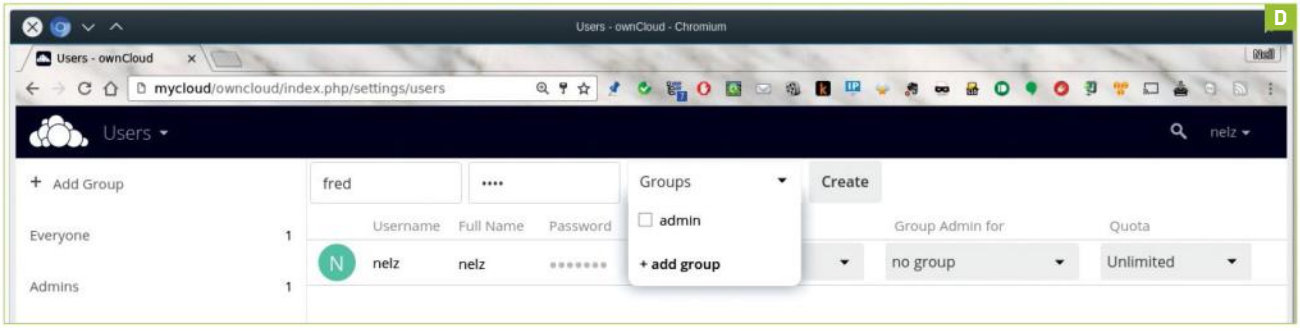
It's also recommended that you use MySQL if you want to use the desktop sync clients. If you want to use MySQL, it's easiest to do this right from the start by running

```
$ sudo apt-get install php5-mysql
```

when you install the rest of the PHP components. If this also installs MySQL for the first time, you are prompted for an admin password for the database—don't forget it. When you load OwnCloud for the first time, the database options include MySQL, where you can pick a database name, along with a username and password. These are used only by OwnCloud for accessing the database—don't use your normal login details. If you start with SQLite, and later decide to switch to MySQL, the OwnCloud command-line tool, occ, has an option to make the conversion for you:

```
$ sudo -u www-data php occ db:convert-type --all-apps mysql oc_admin 127.0.0.1 owncloud db
```

You run it as the user owning the existing database—`--all-apps` simply tells it to convert all apps, not just the enabled ones. The following options are the type of database to create (mysql), the username to admin that database, its IP address, and the name of the database itself. This creates a suitable database in MySQL, migrates your data, and also alters OwnCloud's configuration to use that database.



6 SECURING ACCESS

OwnCloud already has usernames and passwords to control access, but if you are going to open your OwnCloud setup to the world at large, you need to take some extra precautions. First of all, the advice to locate the data directory outside of the web server's scope becomes even more important. If you cannot do this for any reason, you can disable access to it by lighttpd by editing /etc/lighttpd/lighttpd.conf, and adding:

```
$HTTP["url"] =~ "^/owncloud/data/" {
  url.access-deny = ("")
}
```

» This blocks all access to the data directory. Then you should disable all directory listings by adding:

```
$HTTP["url"] =~ "^/owncloud($|/)" {
  dir-listing.activate = "disable"
}
```

» OwnCloud includes an Apache .htaccess file to implement these measures, but lighttpd does not use .htaccess files, so you have to put everything in the configuration file, then restart the server. Many server administrators discourage the use of .htaccess anyway, as it means every page load causes them all to be parsed again, while configuration files load only once at startup.

» The other important step for remote usage is to use HTTPS instead of HTTP. You can do this with a self-signed certificate. First, you need to create a certificate:

```
$ cd /etc/lighttpd
$ sudo openssl req -new -x509 -keyout server.pem -out server.
pem -days 365 -nodes
$ sudo chmod 400 server.pem
$ sudo lighttpd-enable-mod ssl
```

» While you're at it, add HSTS (HTTP Strict Transport Security) by creating the file conf-enabled/10-hsts.conf, containing:

```
server.modules += ( "mod_setenv" )
$HTTP["scheme"] == "https" {
  setenv.add-response-header = ( "Strict-Transport-
Security" => "max-age=31536000")
}
```

» You can change the name and location of the certificate file as long as you edit the setting for sss.pemfile in 10-ssl.conf to match. Using a self-signed certificate causes your browser to warn you, until you add an exception, but if you are only using it to access your own files from outside, that isn't an issue. For more serious use, a proper SSL certificate is a better idea. Once you restart the server, you can access it as https://your.server/owncloud.

» You also have to configure your router to forward the relevant incoming port to your OwnCloud server. This is normally port 80 for HTTP, and port 443 for HTTPS. If you want to enforce HTTPS usage when connecting from outside, only forward port 443 on your router.

» There is another way to handle access from outside: to use a VPN. It is beyond the scope of this article to explain how to do that, but if you regularly connect to your network from outside, running OpenVPN or using a service such as ZeroTier One saves you having to set up and secure for external access for each of your services.

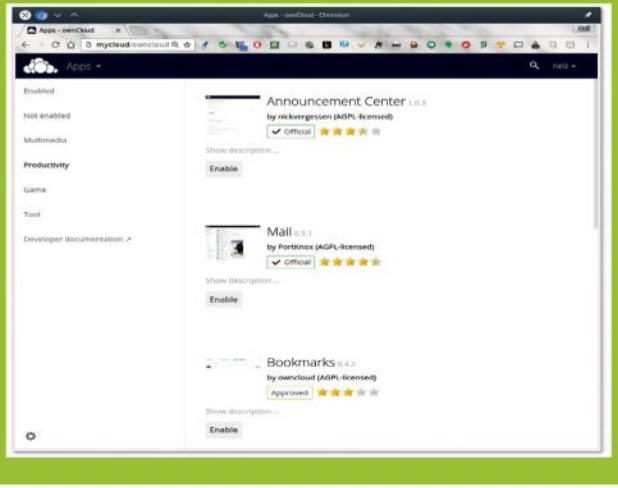
7 EXPLORING OWNCLOUD

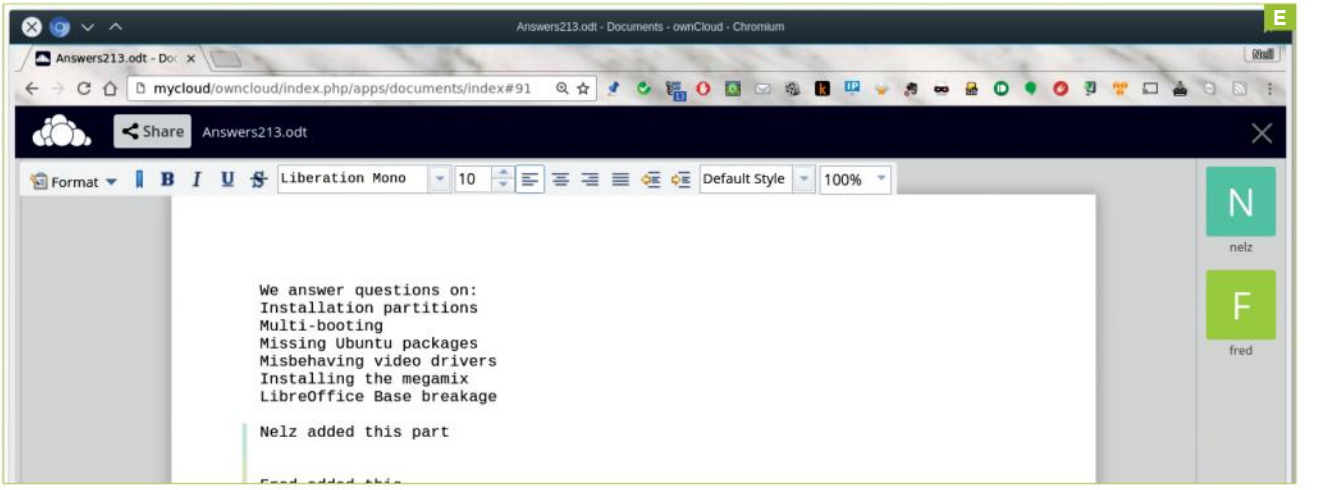
So, you have set up OwnCloud, and you can upload and download files, but you could do that with just a web server. What makes OwnCloud useful are its abilities to share files and other data. Click on the drop-down menu by your user name, and go to the "Users" page to create users and groups. Each user has their own password, and

APPS GALORE

When you went into the Apps section to add the documents app, you may have noticed a lot of other apps. Most of the apps are installed but not enabled. You can either browse the categories, or use the search option to find interesting apps, then you just need to hit each app's "Enable" button to make it available.

The Productivity section includes the usual calendar, contacts, bookmarks, notes, and to-do list type apps, but there are more available, including an email client, so OwnCloud can double as your webmail, too. There is already a photo gallery app in the default OwnCloud setup, but the Multimedia section includes an enhanced option, as well as a music player. All of this can be shared with other users as you desire.





just as with the Linux system, they can be collected into groups. Once you have created a user, you can share folders and files with them. Click on the share icon to the right of the file or folder name to open the sharing pane. Type part of a user or group name to see a list of matches, then select the one you want. It's also possible to share with a user on another OwnCloud server by typing "user@server.address/owncloud." Once you have added a user to share with, a number of checkboxes enable you to specify what they can do with that share: whether they can re-share it with others, and whether they can edit, overwrite, or delete files you created.

» If you just want someone to be able to download a file, without giving them access to the rest of your OwnCloud, check the "Share link" box; this gives you a URL that you can pass to them to view or download the file directly. If you are concerned about others using this link, you can password-protect it or set an expiry date.

8 COLLABORATION

Being able to let others view and upload files is good, but OwnCloud also allows for collaboration [**Image D**]. At the moment, this is limited to word processor documents in ODT, DOC, and DOCX format. The first step is to enable the Documents app: select "Apps" from the drop-down menu at the top-left of the display, type "documents" in the search box, then press the "Enable" button for the app. Go back to the drop-down menu, and you'll see a new option for "Documents." From here, you can open an existing document, create a new one, or upload one from your computer. See the "Share" button at the top of the word processor display? Avoid it, as it doesn't work in the current release. Instead, go back to the "Files" view, and share the file from there. Make sure you enable the "Can edit" and "Can change" options, then each user can open the file in their Documents app, and make changes. As other users edit the file, you can see the changes in your editor, color-coded to show which user made which change [**Image E**].

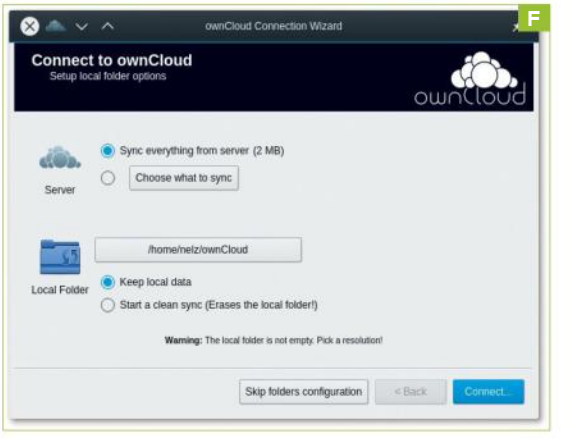
9 KEEPING IN SYNC

Keeping your cloud documents synchronized with your desktop and mobile computers is easy, as there are synchronization programs for the three major desktop operating systems (Ubuntu, OpenSUSE, and Fedora), as well as Windows and Mac, along with mobile apps for various platforms. Install them in the usual way, then add an account with your server address and login details. As with the browser access, if you are using a self-signed SSL certificate, you are asked whether to accept it the first time you connect. Then you can choose which folders to sync between the computer and server. The default is to keep a copy of everything on the server in ~/ownCloud, but you can choose individual directories to sync. You can sync whichever folders you want; there is no arbitrary limit as with most commercially provided servers, especially their free versions. Once set up, the desktop client [**Image F**] sits in the system tray, and notifies you when files are updated. Setting up the mobile clients is similar, but if you want to be able to sync when out and about, you need to set up your router, and OwnCloud, for external access.

» There's a couple of tweaks you may want to make. We mentioned disabling the lighttpd placeholder page: You can delete the index.lighttpd.html placeholder file from the DocumentRoot, then prevent any directory listings of that URL by adding this to /etc/lighttpd/lighttpd.conf:

```
$HTTP["url"] =~ "^/$" {
  dir-listing.activate = "disable"
}
```

» The default maximum file upload size is 512MB, which is possibly sufficient for Internet use, but you may want to exchange larger files over your LAN. You can change the limit in the "File Handling" section of the "Admin" page. If you see a message about missing permissions, make sure owncloud/.user.ini is owned by www-data, and restart the server. It may take a few minutes for this change to take effect. If you start uploading large files, you'll soon fill the Pi's SD card. If you attach a USB hard drive, copy the contents of /var/owncloud/data to the drive, then mount the drive at /var/owncloud/data, you can have as much space as you want. That should get you started with OwnCloud, but there are plenty of other options to explore.



SUBSCRIBE TO MAXIMUM PC

THE GO-TO RESOURCE FOR PC ENTHUSIASTS...

CHOOSE YOUR PERFECT PACKAGE

MAXIMUM PC
SPEED UP WINDOWS
Clear out the junk to boost performance
Optimize your drives for faster boot times
Get a faster system in a few easy steps
HUGE SCREEN SHOWDOWN
SPEED UP WINDOWS 10

1

THE DIGITAL EDITION

ONLY $9.00

EVERY YEAR

Instant digital access on your iPad, iPhone, and Android device.

MAXIMUM PC
SPEED UP WINDOWS 10
Clear out the junk to boost performance
Optimize your drives for faster boot times
Get a faster system in a few easy steps
HUGE SCREEN SHOWDOWN

2

THE PRINT EDITION

ONLY $24.00

EVERY YEAR

Every issue delivered to your door for a fraction of the store price.

Future

3
COMPLETE PRINT & DIGITAL BUNDLE
ONLY $28.00
EVERY YEAR

Get the print edition of *Maximum PC* delivered direct to your door, and instant access on your iPad, iPhone, or Android device.

MAXIMUM PC
2017 TECH PREVIEW
Revealed Hardware that redefines the PC
All the gear from Nvidia, AMD, Samsung, Intel, and more!
SPEED UP WINDOWS 10
Clear out the junk to boost performance
Optimize your drives for faster boot times
Get a faster system in a few easy steps
HUGE SCREEN SHOWDOWN
NO.1 HARDWARE

On iOS & Android!

THE EASY WAYS TO SUBSCRIBE...

http://bit.ly/max-subs

Or **call 844-779-2822** (toll-free)

TERMS AND CONDITIONS Prices and savings quoted are compared to buying full-priced US print and digital issues. You will receive 13 issues in a year. You can write to us or call us to cancel your subscription within 14 days of purchase. Your subscription is for the minimum term specified, and will expire at the end of the current term. Payment is non-refundable after the 14-day cancelation period, unless exceptional circumstances apply. Your statutory rights are not affected. Prices correct at time of print and subject to change. Call center opening hours are Monday to Friday 8am–7pm, and Saturday 10am–2pm EDT. For full terms and conditions, please visit http://bit.ly/magtandc. **Offer ends: June 30, 2017.**

The home of technology

techradar.com